

# **Beacon Südtirol - Alto Adige**

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# Beacon Network Final Report

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PROVINCIA AUTONOMA DI BOLZANO ALTO ADIGE AUTONOME PROVINZ BOZEN (1) SÜDTIROL

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# 1 - Introduction

In the WP 4 "Beacon Network" the Beacon project team in cooperation with Konverto has:

- created a beacon network well distributed over the whole South Tyrol;
- developed the software tools needed to properly manage and use the beacon network. During the project the following tools have been developed:
  - a **Beacon Admin Web-App** that can be used by the beacon network managers to manage and have an overview of the network;
  - a Beacon Admin Android App tach can be used by the beacon network managers to manage and have an overview of the network. Moreover the Android Application allows the network managers and maintainers to configure (e.g. change power signal and frequency of transmission, enable/disable telemetry functionality, etc.) the beacons;
  - a set of **APIs** that can be used by the developer to retrieve information about the single beacons;
  - an **iOS SDK** and an **Android SDK** that can be used by the app developers to interact with the beacons and easily get information about it. Moreover the SDKs allow the trusted users to get the battery status of the beacons and store it in the backend.

In this final report the user will find:

- the project overview;
- the description of the activities;
- the lesson learned;
- suggestions for the maintenance;
- proposals for future developments.

### **1.1 - Project overview**

This document describes the activities of the 4th Work Package of the project "Beacon Südtirol - Alto Adige". The aim of the work package is to build a physical network of 3.500 Beacons and to distribute these Beacons over the whole South Tyrol. Furthermore, within the 4th Work Package the software tools which allow the use and the administration of the network will be developed.

The 4th work package includes the following activities:

- the identification of the point of interest for the beacons;
- the installation of 3.500 beacons distributed over the whole South Tyrol;









- the development of Open Source libraries (iOS and Android) that can be used by stakeholders which will use the installed beacons in their apps;
- the development of an Open Source web tool to manage and maintain the beacon network:
- the development of an Open Source Android app to manage and maintain the beacon network;
- the creation of a plan for the maintenance and the future development of the beacon network.

# 1.2 - Project history

The Beacon Südtirol - Alto Adige project started officially on 1st May 2018. The 8th of June 2018 NOI Techpark organized a Kick Off event in order to present the project and get in contact with the stakeholder interested in the beacon network. NOI Techpark, through a public call for point of interest, started the collection of Point of Interest to be equipped with beacons. Every institution and/or company interested in beacons had the possibility to manifest their interest by writing an email at the following email address info@beacon.bz.it and sending the information about their point of interest.

The 30th of October 2018 in a public tender KONVERTO was awarded for the creation and the maintenance of the Beacon Network and the development of the software tools needed for the use and the maintenance of the network. The public tender was divided in the following two parts:

- 1. the development of the software components;
- 2. installation and maintenance of the beacon network.

The 12th of December 2018 NOI Techpark organized a kickoff meeting with KONVERTO in order to:

- plan the development of the software tools;
- plan the installation of the beacon network.

In order to plan the installation of the beacons, the first call for point of interest was closed at the end of January 2019. All requests collected after this date where inserted in a waiting list.

Originally, the whole project should have been completed within 30th of June 2019. Considering some unexpected problems (the problems will be mentioned and described in detail in the lesson learned section of the present document) emerged during the implementation of the project, NOI Techpark, Autonomous Province of Bolzano, KONVERTO and ERDF fund agreed a project extension until the 31st of January 2020.



The creation of the software packages was completed in March 2019 in accordance with the original project plan and, after a testing period, was officially handed over by the project owner (NOI Techpark) on 21st of May 2019.

The present project was officially accepted and completed by the project owner (NOI techpark and Autonomous Province of Bolzano) on 29th of January 2020. The installed Beacon network was taken over into regular operation by the Autonomous Province of Bolzano and will be maintained in the next five years.

# 1.3 - Project Methodology

For the implementation of the 4th Work Package the project team used agile methods. In particular the method was helpful in order to coordinate the software development activities and reduced the risk of problems during this phase of the project.

In concrete SCRUM was used with an iteration of 2 weeks. This results in the following advantages:

- high flexibility in software development;
- high transparency about the project progress (Jira)
- "Shippable Product" every two weeks
- high "time to market"
- high customer satisfaction.



#### Figure 1: the SCRUM method.

For the software development NOI Techpark and KONVERTO did a sprint review and sprint planning every two weeks. After each sprint NOI Techpark received the produced output to test and give feedback for further development. A shared Scrum board on github (<u>https://github.com/orgs/noi-techpark/projects/7</u>) was in use to see the progress of the work and to have a central backlog. The software development activities were concluded in 6 sprints.









After the conclusion of the software development activities KONVERTO and NOI Techpark decided to reduce the sprint frequency to one meeting per month. In this phase of the project, during the sprint meeting, KONVERTO and NOI Techpark reviewed the beacon installed during the sprint, planned the next steps and shared the critical aspects. This was very helpful in order to identify the critical aspect, identify possible solutions as fast as possible and reduce the risk of further delays in the project deadlines.



# 2 - The Software Components

The Beacon project developed three separate software packages. Two of them (the Beacon Maintenance Android app and the Beacon Maintenance web app) are mainly targeted to the maintenance of the Beacon Network and one (the iOS and Android SDK) was targeted to Developers to use the Beacon Network in their apps. All three of them have been developed with a special focus on usability, extensibility and using only open source technologies.



Figure 2: Simplified architecture of the software packages.

In Figure 2 is described the general architecture of the software infrastructure that has been developed to manage and use the Beacon Network. As said before the three main components are:

• the Beacon Maintenance web app (Beacon Open Source CMS in Figure 1) which is the core of the entire system since allows to









- retrieve all beacons information (e.g. ID, UUID, Major, Minor, etc. ) from the API of the beacon producer;
- view and manage all beacon information;
- manage the beacons configuration;
- retrieve information of each beacon:
- open, manage and close issues.
- the Beacon Maintenance Android app which allows to:
  - view and manage all beacon information;
  - manage the beacons configuration;
  - upload configuration via Bluetooth on the beacons;
  - get information about the beacon status;
  - open, manage and close issues.
- the Beacon SDKs (Android and iOS) allow the developers to easily use the beacons in their apps. Moreover the trusted user, using the SDK, are allowed to read the battery status of the beacon and forward it to the maintenance system.

# 2.1 - The Beacon Maintenance web app

The Beacon Maintenance web app (see Figure 3) is the tool that the beacon maintainer uses in order to control and manage the Beacon Network.



Figure 3: the Beacon Maintenance web App.

According to the use cases defined during the kick off meeting, an user of the application is able to:

easily configure the signal range or signal strength of a Beacon device and the parameters needed to support the iBeacon and the Eddystone standard









- assign a GPS position to each installed beacon and, for indoor beacons, the floor where the beacon is installed:
- define the GPS coordinates and, in case of indoor beacons, the floor of the point of interest associated to each beacon;
- list and manage the parameters UUID, Major, Minor, GPS position, the possible floor, the battery status and the status of each beacon device
- list the beacons on a table or on a map view;
- report beacon network problems (e.g. low battery, broken beacon, etc.), simply by sending an e-mail to a dedicated address (e.g. support@beacon.bz.it);
- be able to receive, process and close issues;
- assign a description and a picture of the installation position of each beacon of the network:
- manage user access to the web and Android application.

The Beacon Maintenance web app is reachable at the following link:

### admin.beacon.bz.it

The Beacon Maintenance web app also provides an REST API for the Beacon Configuration App and the Beacon SDK. The beacon API are reachable at the following link:

### api.beacon.bz.it

The source code of the admin web-app is released on GitHub under the GNU AFFERO GENERAL PUBLIC LICENSE 3.0 and available at the following link:

### github.com/noi-techpark/beacon-suedtirol-administration-webapp.

More information about the Beacon Maintenance web app and its usage are available in the "Beacon Admin Web-app - User Manual" the can be downloaded from the project webpage from the following link:

beacon.bz.it/wp-4/maintenancetools.

# 2.2 - The Beacon Maintenance Android app

The Beacon Maintenance Android app (see Figure 3) is used by the field technician and the beacon maintainers to manage the beacon network. The Android application has similar functionalities as the Beacon Maintenance web app. The Android app allows the technician to configure the beacons uploading the signal strength, the transmission frequency and activating/deactivating the telemetry via bluetooth.













Figure 4: the Beacon Maintenance Android App.

According to the use cases defined during the kick off meeting, an user of the application is able to:

- easily configure the signal range or signal strength of a Beacon Device and the parameters needed parameters to support the iBeacon and the Eddystone standard;
- flash those parameters to the beacons;
- assign a GPS position to each installed beacon and, for indoor beacons, the installation floor
- define the GPS coordinates and, in case of indoor, the floor of the point of interest associated to each beacon;
- list the parameters UUID, Major, Minor, the GPS position, the possible floor, the battery status and the status of each beacon device;
- list the beacons on a table or a map;
- report beacon network problems (e.g. low battery, broken beacon, etc.) by creating an issue;
- receive, process and close issues;
- assign a description and a picture of the installation position to each beacon.



The Beacon Admin App is released on the Google Play Store under the following link:

### play.google.com/store/apps/details?id=it.bz.beacon.admin

The source code of the Beacon Admin Android App is released on GitHub under the GNU AFFERO GENERAL PUBLIC LICENSE 3.0 and available at the following link:

### github.com/noi-techpark/beacon-suedtirol-administration-android

More information about the Beacon Admin App and its usage are available in the *"Beacon Admin Android app - User Manual"* the can be downloaded from the project webpage from the following link:

beacon.bz.it/wp-4/maintenancetools.

# 2.2 - The Beacon SDKs

The Beacon SDKs (provided for Android and iOS) are libraries for App developers which can be used to easily interact with the beacon network.

Through the beacon SDK the developer are able to:

- get an easy to use SDK to monitor and range beacons;
- retrieve additional information about the beacon (not only the iBeacon and Eddystone parameters);
- read the battery status and send it to the system (only developer with trusted user credentials);
- wrap the beacon manufacturer SDK.

The information about the beacon (e.g. UUID, Major, Minor, etc.) are cached on the phones for the offline usage of the app that uses the library.

The source code of the Android SDK is released on GitHub under the GNU LESSER GENERAL PUBLIC LICENSE 3.0 and available at the following link:

github.com/noi-techpark/beacon-suedtirol-mobile-sdk-android.

The source code of the iOS SDK is released on GitHub under the GNU LESSER GENERAL PUBLIC LICENSE 3.0 and available at the following link:

github.com/noi-techpark/beacon-suedtirol-mobile-sdk-ios.



# **3 - The Beacon Network**

As mentioned in the Introduction chapter, the main goal of the 4th Work Package of the Beacon Südtirol - Alto Adige project is to create a network of 3.500 beacons well distributed over the whole South Tyrol.

As can be seen in Figure 5 the Beacon Network installed within this work package are well distributed over the whole South Tyrol.



Figure 5: the south tyrolean Beacon Network.

### 3.1 - The installation process

The identification of the stakeholder interested in beacons began at the kick off meeting where a call for Point of Interest has been presented. The first call of Point of Interest was closed at the end of January 2019. The following institutions/ companies answered to the first call by sending their point of interest via email:

- 67 tourism associations of South Tyrol (under the direction of IDM);
- the "Landesverband der Handwerker" (LVH-APA);
- the "Handels- und Dienstleistungsverband Südtirol" (HDS);
- Dolomiti Superski;
- the Messe Bozen Fiera di Bolzano;
- the Blueslemon project (LP 14 project of Gruppo FOS and MAV Tech);
- Systems;
- Athesia;



- the medical center of Bolzano;
- the NOI Techpark.

In Table 1 are shown the number of the beacon requested by each institution or company that answered to the first call of Point of Interest.

Institution / Company	Number of Beacons
Tourism Associations (IDM Südtirol)	1.400
LVH-APA	150
HDS	550
Dolomiti Superski	100
Messe Bozen - Fiera di Bolzano	150
Blueslemon Project	100
Systems	10
Athesia	65
Medical center of Bolzano	350
NOI Techpark	800
Total	3.675

**Table 1:** result of the first call for Point of Interest.

After the first call for Point of Interest, in order to plan and share the installation methodology, dedicated meetings with the single institutions and companies have been organized.

Moreover, to test the installation procedure for the Tourism Organizations in February 2019 pilot installation sessions have been organized with the Merano, Prissian and Castelfeder Tourism Organizations. The cooperation with these pilot communities was very successful and the installation of the beacons in these locations was completed on time. The aim of these pilot installations was to gain practical experience and to test the different installation methods of the beacons on different surfaces. Furthermore, the aim was to test the optimal processes and communication channels for the planning of further installations.

Once the pilot installation has been concluded the roll out process has been finalized and shared with all the companies and institutions involved.

The installation of the beacons (roll out) in the other zones of the tourism associations started with end of April 2019, discussions were held with the other organizations or companies. With individual organizations (e.g. Gruppo FOS and Systems) this proved to be very easy and the beacons could be installed or



handed over in a timely manner. With other organizations the process was more effort demanding. NOI Techpark and KONVERTO where strongly in contact with the most critical organizations and companies.

Setting of an ultimatum (due to the approaching end of the project) led to a final decision of these stakeholders. Some of them (e.g. HDS, Athesia, Dolomiti Superski) decided not to participate directly in the project and be only observers. Others decided to take over the beacons assigned to them and apply them themselves (e.g. LVH-APA, the medical center of Bolzano).

In order to collect other stakeholder interested in beacons a second call for Point of Interest was opened during the summer 2019 and the following organizations and institutions answered to it:

- Bletterbach Schlucht;
- Eurac Research:
- Centro Trevi;
- Oberalp;
- Castel Mareccio;
- Belka.

In Table 2 are shown the number of the beacon requested by each institution or company who answered to the second call of Point of Interest.

Institution / Company	Number of Beacons
Bletterbach Schlucht	300
Eurac Research	40
Castel Mareccio	20
Oberalp	100
Centro Trevi	65
Belka	10
Total	535

**Table 2:** result of the second call for Point of Interest.

The second call for Point of Interest allowed the allocation of the beacons left over by the companies and organizations that, considering the effort to install the beacons, decided to not become directly part of the Beacon Südtirol - Alto Adige Project.

The rollout of the beacons over the whole South Tyrol, despite some difficulties that will be described in a dedicated section, has been concluded the 29th of January 2020.





In Figure 6 are reported some pictures of how the beacons are installed in different contexts like for example indoor installation, in cultural places, in naturparks and near the streets.

AUTONOME.

SÜDTIROL

PROVINZ

BOZEN

PROVINCIA AUTONOMA

DI BOLZANO

ALTO ADIGE



Figure 6: some examples of installations.

### 3.2 - The installation result

As a result of the 4th Work Package a Beacon Network over the whole South Tyrol has been created. As can be seen in Figure 5 the network covers the whole region. The beacon has been installed in 67 different Tourism Organizations which involved more then 100 municipalities.



In Table 3 are summarized the number of beacons that have been installed and/or handed over divided per organization or company.

Institution / Company	Beacons handed over	Installed Beacons
Tourism Associations (IDM Südtirol)		1292
LVH-APA	100	
Eurac Research	40	
KONVERTO	1	
Castel Mareccio		13
Belka	10	
Messe Bozen - Fiera di Bolzano	81	69
Blueslemon Project	100	
Systems	10	
Centro Trevi	65	
Medical center of Bolzano	350	
NOI Techpark	703	666
Total	1460	2040

Table 3: result of the first call for Point of Interest.

The single beacons can be queried live via the administration Webfrontend developed within the project and available at the following link:

### admin.beacon.bz.it

Moreover the distribution of the beacon can be queried also on the project website at the following link:

#### <u>maps.beacon.bz.it</u> .

Finally the app developer can query the information about the beacon by using the iOS and Android SDK provided by the project or use the dedicated swagger API:

#### <u>api.beacon.bz.it</u> .

# **3.3 - The maintenance during the project**

In the period from the installation of the first beacons in April 2019 until the end of the Beacon Südtirol - Alto Adige Project, there have been no significant



disturbances of the network. Only once a beacon had to be replaced due to malfunction. Occasionally, malfunctions occurred during installation, but these were usually resolved by removing and reinserting the batteries or by changing the battery.

During the Christmas season, a system failure occurred in the Merano area during the deployment of a Gamification APP. The reason was primarily a bug of the SDK that will be described in the Lesson Learned section, a misconfiguration of the API and the database accesses, too low performance of the backend and an incorrect implementation of the SDK in the APP. All these problems have been solved thanks to a great cooperation between NOI Techpark, KONVERTO and the app developer of the Merano Christmas Crime.



# 4 - Problems, solutions and lesson learned

This chapter collects the main problems, the solution and the lesson learned of the activities of the 4th Work Package of the Beacon Südtirol - Alto Adige project.

In any case the project was a success and there were only some small issues that, thanks to the great cooperation of NOI Techpark and KOVERTO could be solved without any negative effect on the project.

### 4.1 - Problems and solutions

This section is dedicated to the problems and the difficulties bumped up during the implementation of the software tools and the installation of the beacons. Moreover, for each problem or difficulty, it will also describe the solution identified by the project team. A good cooperation between NOI Techpark and KONVERTO allowed us to successfully resolve all problems and difficulties.

### 4.1.1 - Beacon Android SDK – Additional information

While putting the first applications on production the project team identified a problem with the background worker of the SDK. The background worker which synchronizes the additional information for offline usage was configured wrong. Each time when the apps (using the SDK) started, a new worker was created and registered in addition to the existing one. This led to an increase of traffic to the API endpoint which crashed causing a downtime of the system.

To get rid of the problem a new Version of the SDK had to be released which fixed the problem and also unregistered the existing workers. Moreover the API where optimized in order to be able to manage properly a higher traffic of request and limiting request coming from a single device. Thanks to this optimizations the problem was solved.

### 4.1.2 - Beacon CMS – Slow List of all beacons

Once all 3.500 beacons were added to the system, the list displaying the beacons became slow. This was caused by the management of the information loaded in the table and map view of the CMS.

To get rid of this problem the list component displaying the beacons had to be optimized in order to get the information faster.

### 4.1.3 - Installation coordination with stakeholders

The coordination of the installations (agreeing the POIs, making appointments for the installation, meetings with associations, getting the authorizations and



access to the places) in some cases was a difficult challenge. In particular during the installation we found the following problems:

- since in some cases the contact provided by the organizations or the companies was not the one responsible for the locations, were difficult to get appointments with the supervisor of the locations where the beacons were installed;
- some organizations or companies renounced to their beacon during the installation phase;
- In some municipalities any beacon was planned on a private location and we didn't get the authorization by the owner.

In order to deal with this issues, the project team implemented the following countermeasures:

- wrote a how to document with a list of task that the company/organization asking for beacons has to fulfill in order to be able to define a date to install the beacons;
- several meetings with the most critical companies and organizations were organized in order to help them to clarify their doubts and to coordinate the pianification work;
- A second call for Point of Interest has been organized in order to collect other locations to associate to the beacons taken over by some organizations and companies.

### 4.1.4 - Coordination of pilot project

Since the beacons information (e.g. GPS coordinates, Major, Minor, UUID, etc.) where released as open data and the developed tools (e.g. SDK, API, etc.) released as open source, in some cases was difficult to get known about the usage of the beacons and the relative problems.

In order to limit this problem, during the project NOI Techpark decided to activate a customer care support that was able to answer the questions and issues sended by the users and developers at <u>info@beacon.bz.it</u> or at <u>support@beacon.bz.it</u>.

### 4.2 - Lessons learned

Learning from the experience done in this project, the project team was able to identify some optimizations and tricks that could be adopted in future projects in order to further optimize the resources and the activities.

During the coordination with the stakeholder interested in getting the beacons it appears clear that the collection of the information and the coordination of the installation activities was quite effort demanding also on their side. Considering



that, in future projects similar to Beacon Südtirol - Alto Adige, the suggestion is to assign a little budget to this stakeholder for the coordination of the installation activities.

Moreover, as said in the previous paragraph, during the project it was difficult to get in touch with all the stakeholders that used the beacons and help them with their issues. In order to improve this aspects, for future projects, the following countermeasures should be taken into consideration:

- foresee a bigger budget for pilot applications;
- foresee a budget for the support of organizations and companies who are willing to integrate the implemented technology in their services/products;
- a customer care structure should be foreseen starting from the beginning of the project.



# **5 - Maintenance and future development**

Based on the experience during the project, this chapter will define some directive that the Autonomous Province of Bolzano (who will maintain the Beacon Network for the next five years) has to take into consideration. There will also be a paragraph dedicated to possible future developments of the network and the software tools that could help to improve the usage of the instruments developed within the Beacon Südtirol - Alto Adige project.

### 5.1 - Maintenance of the actual network

Since during the project period the maintenance work incurred for the beacon network was negligible. In order to estimate the maintenance costs for the five-year period after the project end the following assumptions has to be made:

- the batteries of the beacons are to be replaced once for each installed beacon over the five-year period;
- 1.8% of the beacons have to be replaced every year due to vandalism, theft or malfunction;
- Once a year the function of the beacons is checked.

Considering that in Table 4 and in Table 5 are summarized the costs for the hardware (battery and beacon).

Asset	Number per beacon	Price per battery	Number of beacons	Total cost
Battery CR2477 (industrial)	2	1,70 €	3.500	11.900,00 €

Table 4: batteries costs.

Considering that not all beacons have been installed outdoors, for the beacon price calculation in Table 5, it has been considered also the Kontakt.io TB18-3 beacon. The TB18-3 beacons have the same technical specification as the TB18-2 (chosen in the project) except the protection factor, since the TB18-3 are IP-50 and the TS18-2 are IP-65. This means that Autonomous Province of Bolzano, in case of indoor beacons broken, can consider changing it with TB18-3 beacon without losing functionalities. This distinction wasn't possible in the project, since due to the shrt project duration, the order of the beacon has been done before the definition of all points of interest.











Asset	Number of replaced beacons <sup>1</sup>	Price per beacon	Total cost
Though Beacon TB18-2	315	26,00 €	8.190,00 €
Though Beacon TB18-3	315	20,00€	6.300,00€

Table 5: beacons costs.

The estimation of the working hours required for the maintenance work is given in the table 6. This estimation does not take into consideration the travel times to and from the site, as these are of course heavily dependent on the location from which the contracted company starts and how many maintenance assignments can be carried out in a single day.

If Bolzano is chosen as the start reference, the beacons furthest away are located within a distance of approx. 110 km. On the other hand, about 26% of the beacons are located in the city area of Bolzano with negligible travel time.

Maintenance type	Estimated time
Battery replacement	17 min
Beacon replacement	10 min
Functional test	6 min

Table 5: time per maintenance assignment.

With these parameters and a defined hourly rate, the expected maintenance costs can be calculated approximately.

### 5.2 - Future developments

As already mentioned, the number of stakeholders involved in the project is very high. Many of them also wish for autonomous management of the sub-network assigned to them. For this reason, the most important functional enhancement is certainly the expansion of the Beacon Maintenance web app and the Beacon Maintenance Android app towards multi-tenant capability. This seems to be the most urgent extension for a successful continuation of the network. This new functionality will also be in case of companies or organizations that want to add their beacons to the network and manage it through the tools developed within the project.

The established network also supports the Eddystone protocol. However, this protocol is not currently in use. The creation of use cases that create additional benefits when using this protocol can further increase the attractiveness of the infrastructure.

<sup>&</sup>lt;sup>1</sup> Estimation based on the assumption defined at the beginning of the paragraph.









There are already some suggestions for improvement in the backlog which should be implemented in future project:

- add user groups and rights management; •
- user registration;
- allow not only the admin user to create new users;
- allow users to change their password function; •
- allow users to reset their credentials in case of forgotten credentials; •
- query beacon status over the Open Data API; •
- migration from Google Maps to OpenStreetMap;
- Currently, adding new beacons (inserting the Order\_ID of Kontakt.io) to the backend is only possible by the administrator. As part of the enhancement to multi-client capability, this function should also be transferred to clients. For example, city administrations could expand their beacon network autonomously by using the existing infrastructure.

The pilot installations in the Castle of Maretsch, including the associated APP, were very successful and have received a great response. It should be possible to transfer them to other castles of the "Bolzano Castles Foundation" without much effort