

		<p>Project title: Development of sensor-based Citizens' Observatory Community for improving quality of life in cities</p> <p>Acronym: CITI-SENSE Grant Agreement No: 308524</p> <p>EU FP7- ENV-2012 Collaborative project</p>
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Deliverable D 6.5

D 6.5 Report on the performance of the products and services when implemented and demonstrated on the EIs

Work Package 6

Date: 06.10.2016

Version: 1.2

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Dissemination level:	PU (Public)

Versioning and contribution history

Version	Date issued	Description	Contributors
0.1	24.08.2016	Initial draft	M. Fredriksen
0.2	25.08.2016	Chapter structure	M. Fredriksen
0.3	26.08.2016	User feedback	M. Fredriksen
0.4	01.09.2016	User feedback Indoor Schools	D. Kocman, J. Robinson
0.5	06.09.2016	Product owner feedback Citizens' Observatory Portal	H. Liu, M. Kobernus
0.6	08.09.2016	Product owner feedback Data portal	Z. Knežević
0.7	12.09.2016	User feedback Public places	I. Aspuru Soloaga
0.8	15.09.2016	Product owner feedback LEO	L. Santiago
0.9	20.09.2016	Product owner feedback Radon sensor	B. Dale
1.0	20.09.2016	Executive Summary	M. Fredriksen
1.1	06.10.2016	Revisited section for public spaces	I. Aspuru Soloaga, I. Garcia Perez
1.2	18.10.2016	Last revision after review	M. Fredriksen

Peer review summary

Internal review 1			
Reviewer	Arne J. Berre (SINTEF)		
Received for review	20.09.2016	Date of review	18.10.2016

Internal review 2			
Reviewer	Johanna Robinson (JSI)		
Received for review	20.9.2016	Date of review	27.9.2016

Executive Summary

CITI-SENSE is an EU FP7 granted project that aims to develop Citizens' Observatories to empower citizens to contribute to and participate in environmental governance. This includes developing, testing, demonstrating and validating monitoring and information systems. Three Empowerment Initiatives, case studies concerning urban quality, school indoor quality and public spaces, have each focused on citizen engagement through relevant products and services. These have been developed internally by project members, but also external and already existing products/services have been used.

Within software development, there is a specific term for the process of collecting and evaluating feedback from the users: The Retrospective¹. During a meeting of the project team at the end of a project, positive and negative remarks about a specific product are being collected and possible ideas of technical solutions for improvement of the product are being discussed. Each case study has collected feedback about the products and services they have used and tested. This feedback has been collected through online questionnaires, interviews and plenary sessions, both with citizens, other stakeholders and project members. Based on the feedback from the retrospective, we can suggest different strategies for improving the products and services to make them work better and to create Citizens' Observatories that will be used also in the future.

One of the main issues in CITI-SENSE was of technical nature. Many of the sensor devices tested and used for collecting observations from the users' immediate environment did not have a stable data connection. Even though this seems to be trivial, it actually was a major barrier keeping the citizens involved and interested. This barrier should be overcome, and it should be resolved and be a core priority for any product provider to ensure that the data communication chain sensors-platform-product-user is trustful, stable and reliable.

A large amount of the comments and feedback regarding the measurement units states that the data was not of such quality that it could be compared to regulative values or official data. Until and if we will have units of high quality, graphical user interface designers and developers should take this as an opportunity to find new innovative ways of presenting data with uncertain quality to non-scientific citizens. Users see great potential and value of collecting data with sensor units and they want to see this data combined with other information available. We should therefore also look into not only showing data stand-alone, but how they can be fed into other resources or be combined with other data sources. With a large number of sensor devices, it might be possible to use machine learning and statistical methods to support both calibration and the management of anomalies and outliers in the measurements.

¹ <https://en.wikipedia.org/wiki/Retrospective>

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1 Introduction

This report is based on feedback and comments collected during the different case studies in the CITI-SENSE project. The project has three Empowerment Initiatives i) Urban Quality, ii) School Indoor Quality iii), Public Spaces, and includes case studies in 9 cities (Barcelona, Belgrade, Edinburgh, Haifa, Ljubljana, Oslo, Ostrava, Vienna and Vitoria-Gasteiz). Each of the case studies collected feedback on what the users liked about the products and services, what they did not like and suggestions of possible improvements. Internal feedback from project members were also given during a consortium meeting where all the CITI-SENSE products were tested internally by the project consortium.

The collection of feedback from both citizens, stakeholders and project members was performed by using a google questionnaire form, conducting interviews and/or plenary sessions. This report focuses on the information obtained from the google questionnaire and the reports from location officers from their feedback sessions and interviews.

The questions from the google form that have been specially considered in this report are:

- **What aspect of this product has been most useful/satisfying?**
- **What aspect of this product has been most disappointing?**
- **Do you have any other comments?**

All answers and reports have been structured into different categories to find similarities among the feedback, both positive and negative. The product owners have, where possible, been asked to comment on and especially focus on this question:

- **Based on these feedback, what improvements have you done or do you suggest?**

Feedback from product owners are not available for the empowerment initiative ii) School Indoor Quality, since they have used mainly external and off-the-shelf products.

This report evaluates the products and services implemented by each Empowerment Initiative and ends with a common conclusion that summarizes the commonalities of problems that need to be solved both from hardware and software side, and provides new ideas of the way forward for creating Citizens' Observatories with the use of technology.

2 Evaluation of products and services for Urban Quality

The goal for the urban quality Empowerment Initiative is to develop and test methods for citizen empowerment in the urban air quality area, with the aim of demonstrating the concept of Citizens' Observatories using innovative technological platforms for monitoring the environment and to obtain improved decision-relevant information to inform citizens and decision makers².

2.1 Little Environmental Observatory



Figure 2-1 Little Environmental Observatory (LEO) hardware (left) and accompanying phone app ExpoApp (right)

The Little Environmental Observatory (LEO) is a unit from Ateknea solutions and consists of a mobile air quality sensor unit and an android smartphone application. The sensor measures temperature, relative humidity, nitrogen oxide (NO), nitrogen dioxide (NO₂) and ozone (O₃). The smartphone application ExpoApp reads the data from the unit and sends the measurements to Ateknea's server when the smartphone has network connection.

For the purpose of this project, the processed data is sent from Ateknea's server to the CITI-SENSE Spatial and Environmental Data Services (SEDS) platform for storage³.

2.1.1 Summary of location reports

This report is a summary based on feedback from the online CITI-SENSE Usability Evaluation form and from the Ljubljana case study, where the case study coordinator (Location Officer – LO) has collected feedback based on interviews and plenary sessions with end users. In total, there were 51 answers regarding the usability of the Little Environmental Observatory toolkit from citizens and 10 from internal project members on the online form.

Positive feedback

The positive feedback can be divided into different categories from personal feelings to technical subjects.

Several people stated the personalization aspect of air quality they got by using this equipment as positive. They found it interesting to move around in their local environment and look at the

² Annex I to contract– “Description of Work”

³ <http://co.citi-sense.eu/CitizensObservatoriesToolbox/SensorsandSensorPlatforms/ServerPlatforms/SEDSPlatform.aspx>

different measurements and the current air quality situation. It was also interesting to be able to do measurements along routes they typically used to bike or walk, and to be made aware of what the actual situation was in their daily lives.

Some felt that going around and making measurements forced them to be more aware of air pollution in general and made them more interested in the topic also on a global level. In addition, it was commented that they felt they were contributing to the subject, that their daily routines felt meaningful when carrying the sensor units and doing measurements.

In addition to just learning about the measurements, people commented also that they learned more about the technology behind, how air quality levels were calculated and how the communication worked between the different devices.

Several people found the sensor unit small and easy to use. Some highlighted the fact that it was mobile, did not have too many buttons which made it easier to use. The same was said for the ExpoApp, a «nice looking app» with «great potential».

Much of the positive feedback was about the potential of use for this kind of air quality measurement tools. Some people stated that this could be used for estimating property values or for families looking for a new home, in addition to integration with personal health and changes in daily behaviour to avoid areas with high pollution.

Negative feedback

The main problems people were having in using the ExpoApp, were the unstable connection between the devices. It involved a lot of troubleshooting before they were able to get a good connection between the sensor unit, the phone and the ExpoApp. It also seemed like some phones needed to be manually paired with the sensor unit several times during usage, despite it being designed to pair automatically. In addition, ExpoApp randomly crashed and needed to be restarted and set up again. Several users reported this problem.

It seemed difficult for the users to actually know if the data collected with the sensor unit was correctly uploaded to the server or not. Some people gave the impression that they were not able to use the equipment at all during the campaign period and found the toolkit complicated to use. It might also have been hard to understand that the communication chain led to some delays of presenting the measured values to the end user. This leading to questions if this was real time data or not. In addition, some mentioned that the time stamps displayed on the ExpoApp were not correct and that they found inconsistency in the data they collected, both data loss and measurements of high values in areas where they should not be expected.

Some complained about the battery consumption during the measurements, but also commented that this could have been fixed with having better routines for charging the units.

In addition to the above mentioned issues, several commented that they would like to have more information on the ExpoApp and more detailed information about the parameters they measured like temperature and relative humidity. The sensor unit's design was by some commented as too big to carry around and one had a problem with the on and off button since a pin was needed to use it.

Suggested improvements

The next tables show ideas, suggestions and comments about improving the Little Environment Observatory Toolkit.

Table 2-2 Suggestion for improvements for the LEO toolkit

ExpoApp

Integrate data from different sources, pollen, perception etc.
More information about connection to sensor unit, if everything works
Better battery capacity
Make iOS version
Prevent data from being lost when the ExpoApp is uninstalled
Make the code open source
Stop the app from running when it is not in use
Check that it really works on all android versions promised
Hide unnecessary information
Make GPS more accurate
Turn on mobile data and GPS automatically on the phone
Add the possibility to show both APIN and individual parameters
The user should be able to add the same userID. This seemed to fail
Increase the response time when clicking buttons
Add information about health
Use low energy Bluetooth
Should display temperature data
The app should go on a saving mode when the person does not move
Make it simpler by just having a big START/STOP button
Visualization map on a smartphone
Make a more stable connection sensor-app-server
Trigger an alarm (noise/popup) when pollution is too high
Have more fractionation between the index (APIN) values perhaps numbers form 1-100 would be better
Work on better design, use designer
See ones current locations as well as past tracks
Consider to just upload data to the server twice a day and make it optional to upload it all the time
Make the app to fit different user groups, simpler for children, more information for advanced adults
Indicate what parameter is the most problematic one when showing APIN
Add equipment so the smartphone can be mounted on bikes http://getfinn.com/en/
Add a reminder to charge the device
Make it easier to see if the measurements have been sent or not
Once you press the stop button, give a notification that you had been measuring successfully

LEO sensor unit

Make it waterproof
Make the unit smaller
USB is likely to be lost. Integrated sliding cover instead
Add lights that indicates higher or lower pollution levels
Work on the clip, some found it hard to use the clip.
Adjust the lights. May wake light sleepers when charging
Better light indication for when the unit is working well and the communication is ok
Use low energy Bluetooth
Should measure PM
the device should have multiple attachment options, not only wrist/clip, but both, and more
The device should cost between 50-100€. Max anyone is ready to pay is 200€
Add GPS unit
Decrease the stabilization time so ExpoApp can show data immediately when it is turned on
Use the red light to indicate when the battery is empty

Other

User manual: Make it simple, short and correct
Attached it on Google street view cars/city bikes (with solar panels and GPS)/ city busses

2.1.2 Report from product owner

The LEO nodes

Based on the work carried out during CITI-SENSE, a new platform was developed within the project to promote citizens' engagement by using personal air quality monitors. The main improvement was in the LEO sensor units.

The new hardware is only half of the size compared with the old unit that has been used in the CITI-SENSE case studies⁴. It is called Ateknea Air City monitor (AACM).

⁴ <http://aacm.ateknea.com/aaqm/technicalspecifications>

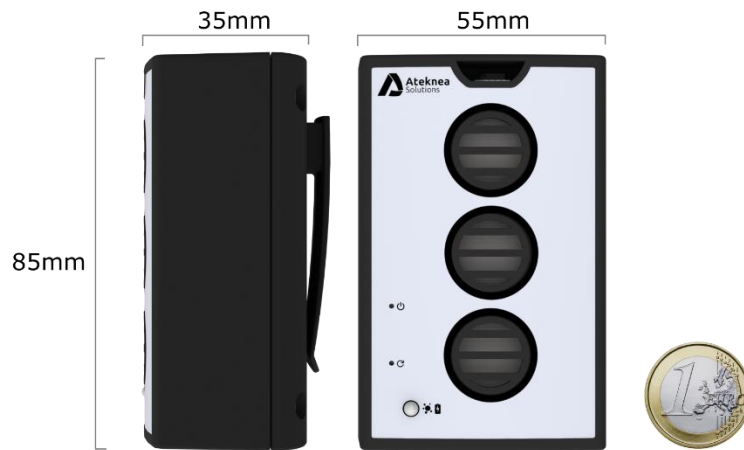


Figure 2-3 AACM sensor node

The new node comes with Bluetooth low Energy. This makes the connection very reliable avoiding also the synchronization issues when using traditional Bluetooth technology. Thus, the battery of the node can last up to 56h of continuous use (with a sampling frequency of 5 seconds), also improving the battery life of the smartphone.

A better electronic was also designed considering the reduction of the noise in order to improve the performance of the low cost electrochemical gas sensors.

The app

A new platform was designed as well. The AACM⁵ (Ateknea Air City Monitoring) platform was developed based on the old platform used for the old units used in the CITI-SENSE project.

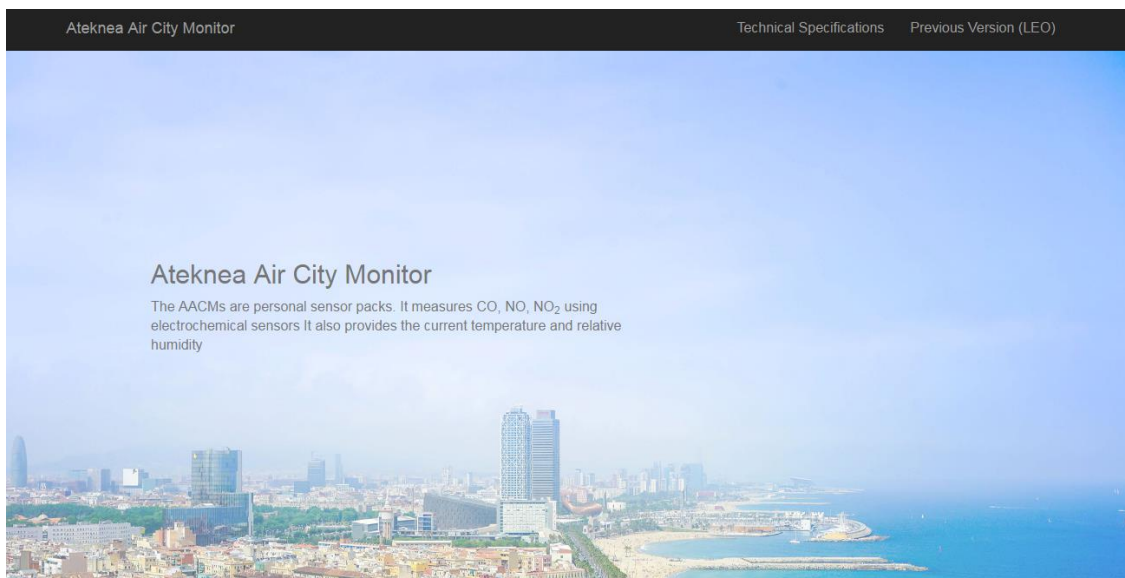


Figure 2-4 Web page representing the platform Ateknea Air City Monitoring

The new app (A2CM, still under development and testing; Figure 2-4) allows the user to easily pair the node with the smartphone. Optimized to reduce power consumption taking into advantage the use of Bluetooth low energy, it was conceived to provide the UX (User eXperience) with a

⁵ <http://aacm.ateknea.com/>

minimalistic design and in-app manual. The last, helps the user to understand how the app works without the need to use other resources such as tutorials or manual.

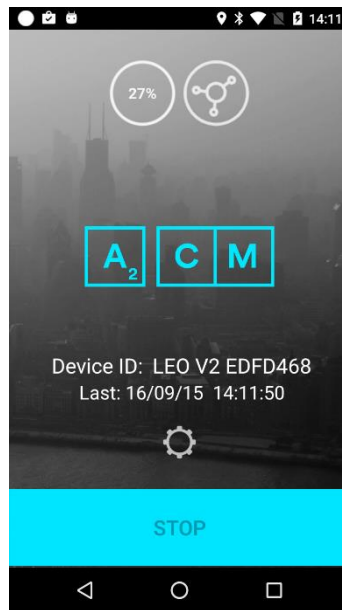


Figure 2-5 A2CM smartphone app

2.2 CityAir

CityAir is a smartphone application built for Android and iOS units. The app gives users the option to add a coloured icon based on their perception about air quality at their current position on a map. The user can suggest a possible source of pollution or add comments for the specific area. The user is also able to see other markers in the area made by other users (see Figure 2-5).

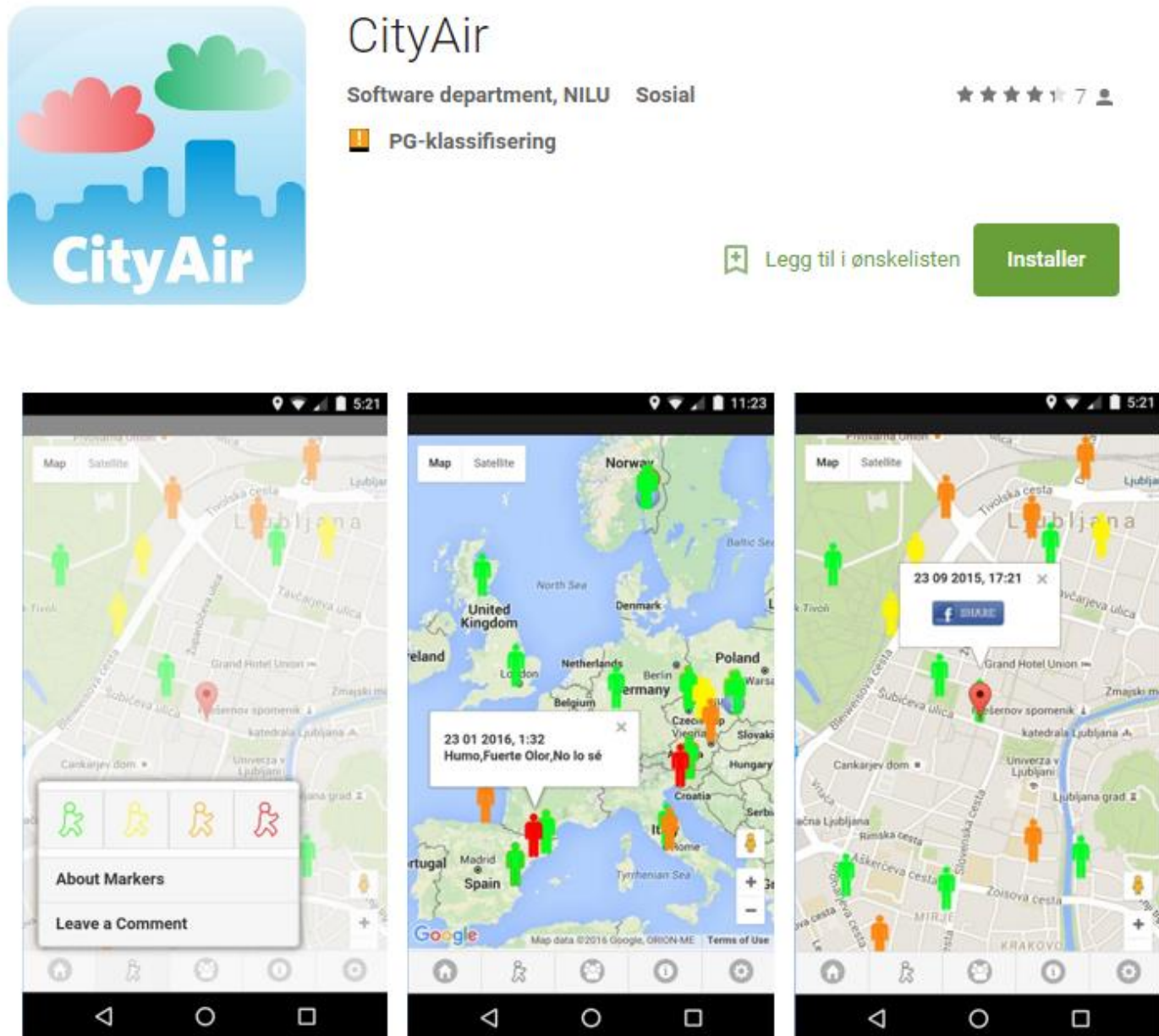


Figure 2-6 CityAir multi-platform smartphone application

2.2.1 Summary of location reports

This report is a summary based on feedback from the CITI-SENSE Usability Evaluation form and from interviews and plenary sessions with end users made in the Ljubljana case study. In total there were 30 answers regarding the usability of the CityAir application made by citizens' users and 8 by internal project member from the CITI-SENSE Usability Evaluation form.

Positive feedback

The positive comments have been categorized into 5 main areas (Figure 2-6):

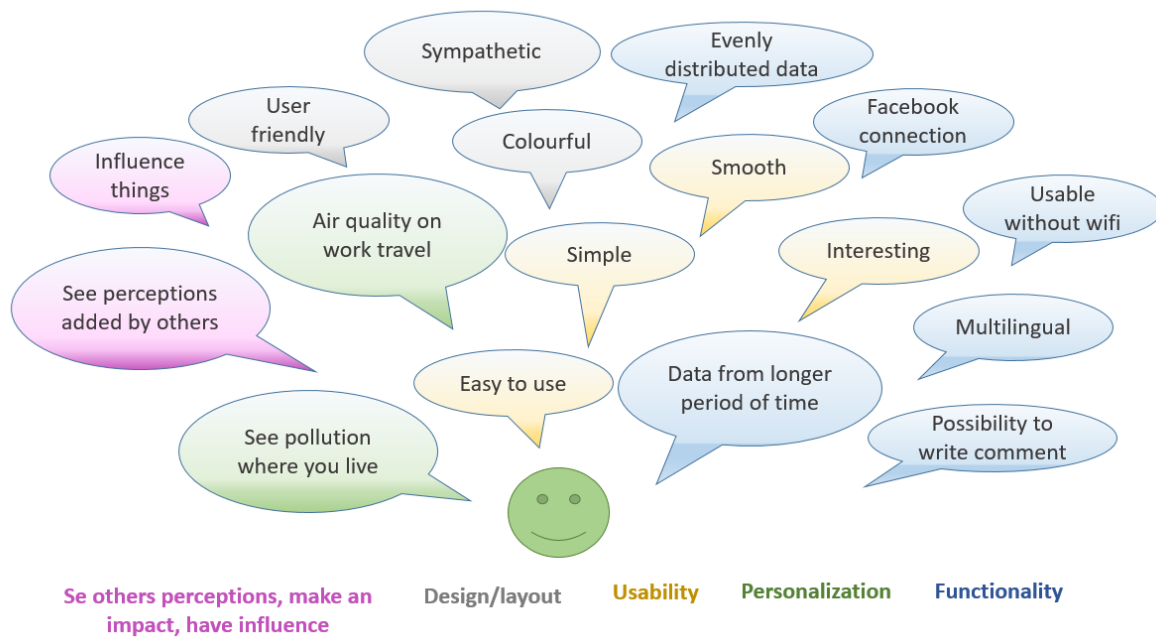


Figure 2-7 Positive user feedback categorized

To see others perceptions, make an impact and have influence seem to be important aspects for the users when using the smartphone application. There were several comments on the functionality for being able to see what other people have reported.

The Usability was stated as easy, the app worked smoothly and does what it is intended to do. The CityAir design and layout got positive feedback for being sympathetic, user-friendly and for the graphical user interface and appearance.

The personalization aspect of the application was that the users can see reports of air pollution right where they live or on their way to work.

The functionality that was found interesting and useful was for example being able to add comments, the possibility to share observations on the personal Facebook wall, and see markers reported for a longer period and view the overall perceived air quality in the city.

Negative feedback

The main negative feedback from the users testing the CityAir application was the lack of a reason to use it. It was commented that despite it was working, simple to use and well-functioning, it was hard to see the purpose of it. The application does not give anything useful back to the end user like conclusions or more information, something that would keep the user to continue using it (Figure 2-7).

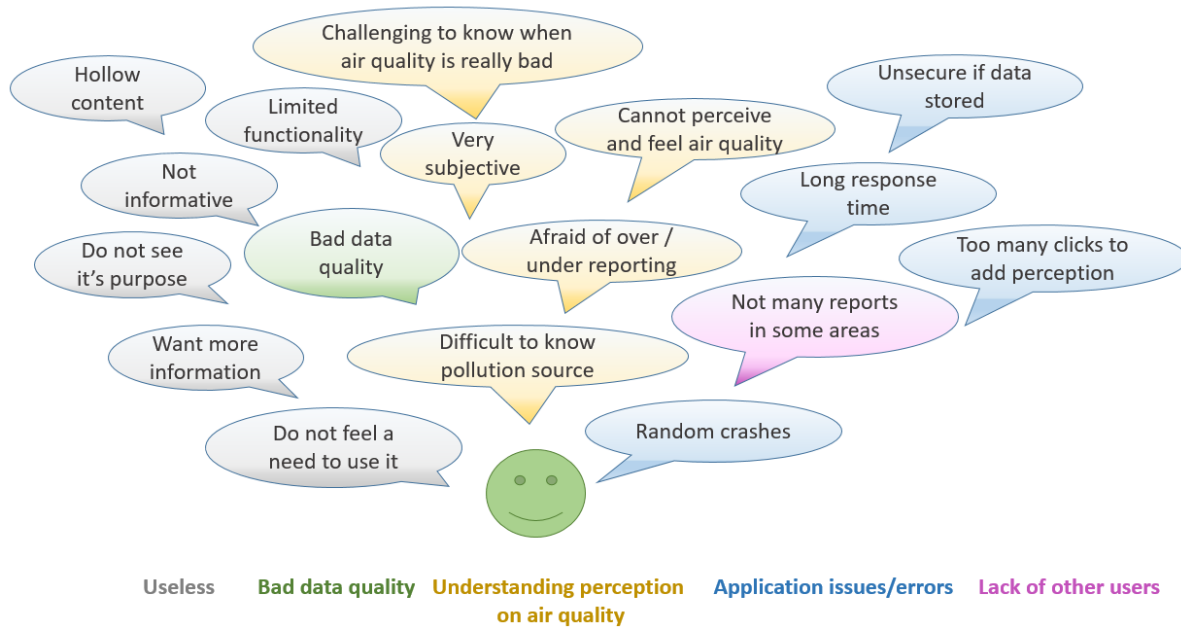


Figure 2-8 Negative user feedback

Another thing that was mentioned several times, was that people found it hard to decide what perception marker to add, some were afraid that their markers could even mislead others. Having a perception about air quality seems not to be easy.

There are also comments about technical issues with the application. The application checks if GPS and mobile networks are available and if not, and gives the user a message to turn it on. It appears to be a problem with storing the markers added by the user. And that this either fails and the application crashes, or nothing happens and the markers seem to be lost.

People’s impressions about CityAir is that it has rather limited functionality and the data generated is maybe not of high quality. Another limitation seems to be the lack of other users of the application. A user can choose to see markers added by other users by filtering on today, last week or last month.

Suggested improvements

The next table shows users ideas, suggestions and feedback about improving the CityAir application.

Table 2-2 Suggestion for improvements for the CityAir app

CityAir
I think it is missing feedback information. When I think the air is bad and report it, I do not get any info back if the air is then actually bad or not. To have a feedback on what is it in the reality.
Would be interested to do thematic mapping (or see some already created maps based on historic data) to show data collected in the past month by perception levels + perception

Center/list of reports ("x from Haifa reported..., y from Oslo ...") either on the web page or facebook. Would attract interest
This can be very nice if you get a bunch of enthusiasts to walk / ride around with. Will give you a much more fine-meshed network of observations.
Combine ExpoApp and CityAir app
Verify (by using models) if the AQ which was reported is anywhere near the "reality" and feed it back to the user
Add a popup reminder to use the app
GPS and data transfer should be turned on automatically
It would be good if one could use this for reporting also other things than just air pollution

2.2.2 Report from product owners

The main issue with the CityAir app appears to be asking the user to report on how she/he perceives the current air quality. But the application does not give them much information in return, and not a sufficient reason to open the app on a regular basis. There are several possibilities to extend the application to support this:

- Creating a simple alert reminder a couple of times a day asking the user to add perception markers, seems like an easy thing to implement, but in this case it is not. Since this smartphone application is developed using HTML5, it does not continue to run in the background when it is not in use. To be able to do that, further work must be done to connect to each platforms' native libraries and their background services.
- Another idea would be to integrate the CityAir into other applications, applications that are opened on a regular basis. This could be google maps, weather services and so on. The CityAir application can also be connected to official air quality data or forecasts and provide information. This can make the app more useful. This can also lead to more people adding their perceptions about the perceived pollution and thus provide a better and detailed map of the city.

It seems that it is not easy for a user to choose an icon with the colour green, yellow, orange or red to indicate their perception about air quality. Some also seem afraid to report something wrong. We could think of other ways of visualising the reporting mechanism. One idea could be to let the user choose the source first and then choose from a scale to indicate the level of bad pollution (as example, see Figure 2-8).

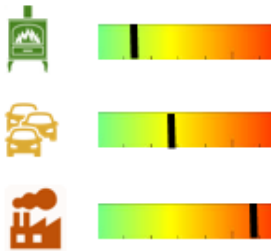


Figure 2-9 Suggestion on perception air quality scaling

There are still some software issues with the CityAir application. The major issue seems to be that there are markers that do not get stored. We found a problem with older devices. CityAir tries to connect to the native library of the current phone's platform to vibrate the phone when a marker is added. To do that we rely on Cordova plugins. We noticed that on some elderly devices, the phone never vibrated and the application through an exception therefore dropped the save-marker functionality. This can be fixed by checking if the library works and then do addition handling if necessary.

There are also native plugins available for turning on GPS and Wi-Fi or 3G and this should be included in CityAir.

2.3 Data visualization web page

The data visualization web page is a web tool to view last measured data from the CITI-SENSE platform. Data collected from each city is displayed; the location and value of static sensors, mobile sensors and perception/human sensors as well as overlaid fusion maps. The measurements can be displayed as a calculated APIN (Air pollution indication) value based on all parameters available, or the APIN based on specific pollution (NO₂, PM_{2.5} etc.).

The user can also track the measurements from his/her LEO (Little Environment Observatory) unit.

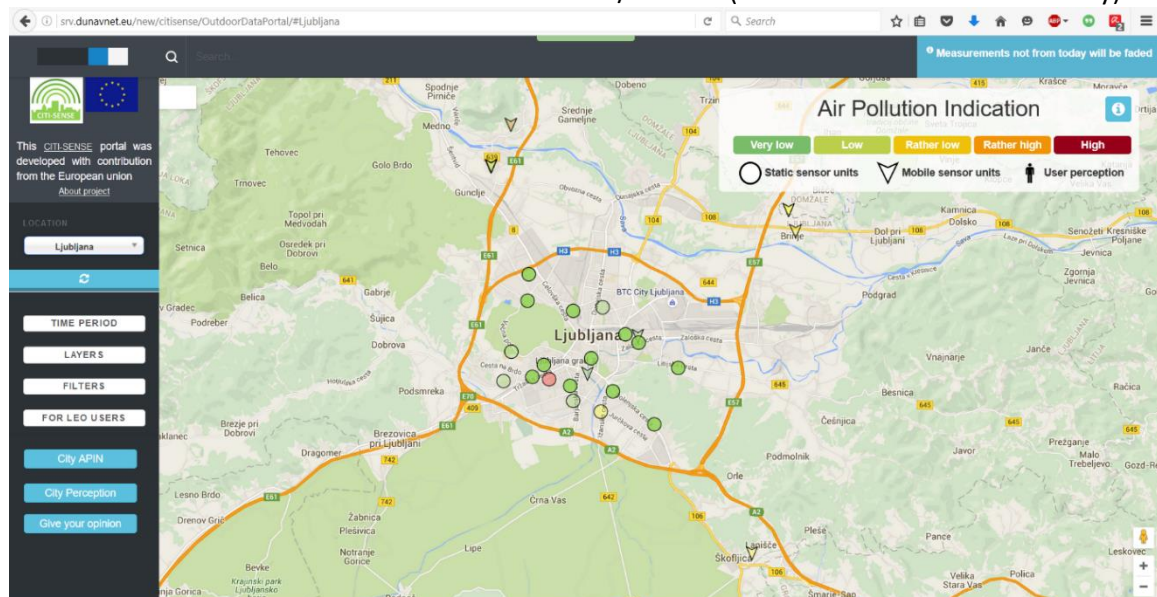


Figure 2-10 Data visualization web page

2.3.1 Summary of location reports

In addition to feedback from Ljubljana workshops, there were 7 answers from external and 6 from internal people from the CITI-SENSE Usability Evaluation questionnaire.

Positive feedback

The main positive comments are related to design, layout, data fusion generated maps and data access in general. Specific point highlighted was the possibility to see the different collected data types displayed together, that being static sensor, mobile sensors and people's perception (see Figure 2-10).

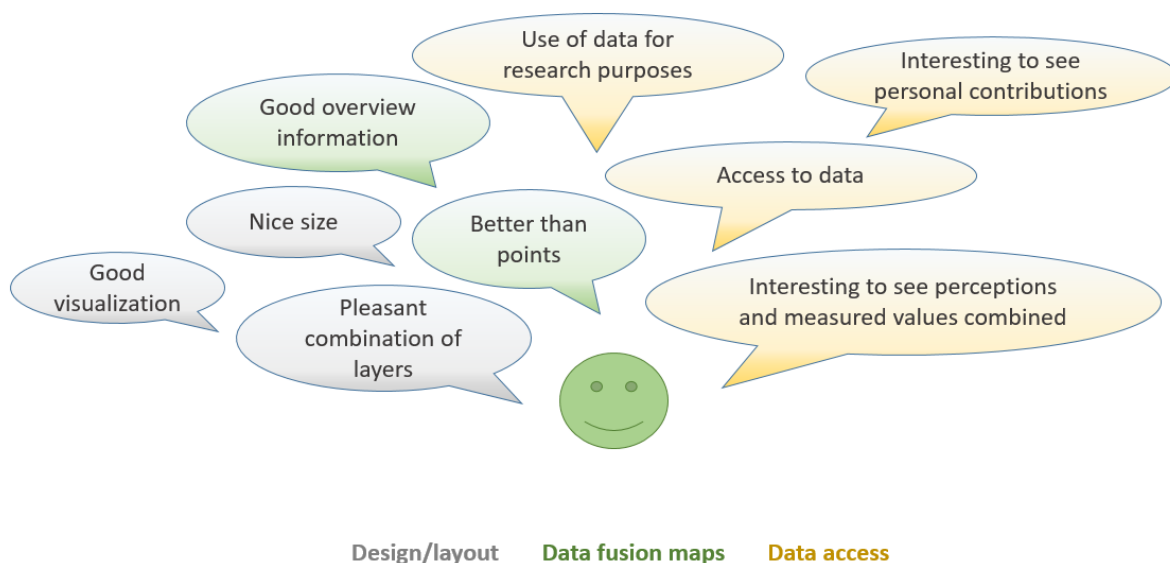


Figure 2-11 Positive feedback

Negative feedback

The negative observations have been split into 5 groups

Performance

The web page seems to have some performance issues and the user received comments like "it takes too long, is slow"

Missing or wrong data

Missing and wrong data might not be a web page problem, but rather missing or wrong data measured by the sensor units, and especially GPS sensors.

Design/functionality

The design and graphical interface of the web page could have been better, since some people noted that they could only see the APIN value and not the components. The web page offers a filter option for displaying the components and not the APIN. This is part of the left side menu. This option seems not to be found by all users

Better content

Users want to be able to see historical data, not only last measured values.

Security

Some have concerns about others seeing their data.

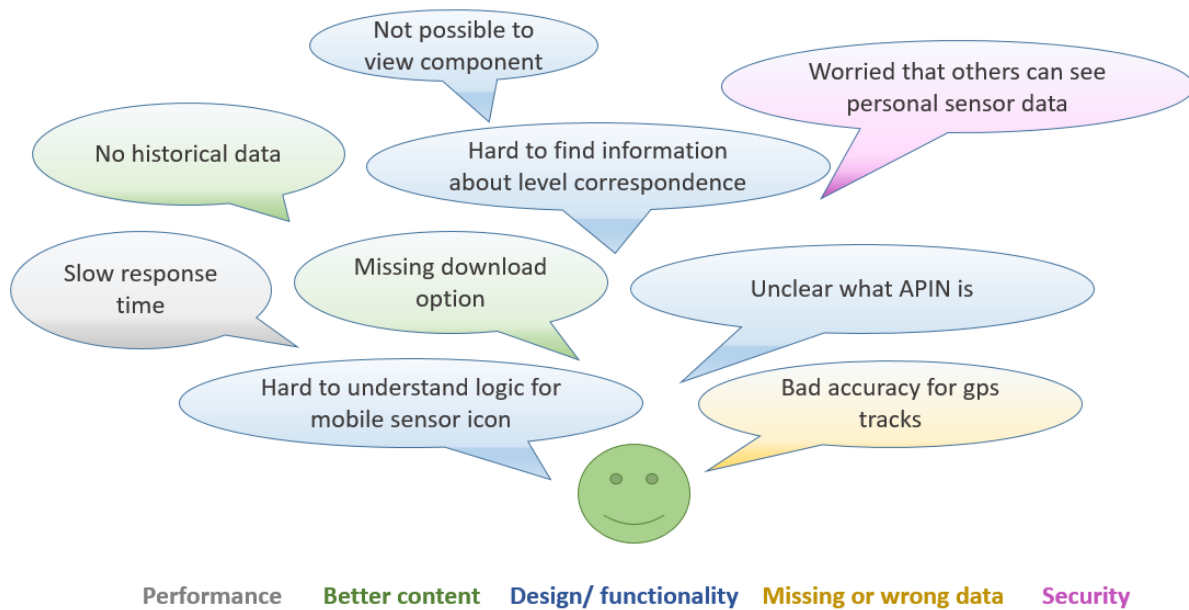


Figure 2-12 Negative feedback

Suggested improvements

The next table show users ideas, suggestions and feedback about improving the Data visualization web page.

Table 2-3 Suggestion for improvements for the Data visualisation web page

Data visualization web portal

Center the screen when choosing unit, SNOWFLAKE should integrate air quality data from AQM for visualisation model purpose (to be more accurate)
About APIN: "it would be good to have it for separate compounds as an option and to have more granularity between the indicator numbers. If it is just the general score which is calculated form different inputs it is nice, but it would be nice if it was from 1-100 for example"
State somehow that the mobile icon displays the last location of a portable device
Add option to see historic data
It would be good to have for each individual parameter limit values for public to know which pollutant responses to which air quality APIN

2.3.2 Report from product owner

Suggested Improvements from product owner

- **DESIGN/FUNCTIONALITY**
 - In info window for mobile sensor units; state that the mobile icon displays last location

- Make APIN explanation better: in a legend, in info window for APIN, in device info window, near main global APIN explanation.
- Make web address simpler.
- **BETTER CONTENT**
 - Make historic data available for users to choose date which they want so they can see desired data.
 - Download data option implementation in sidebar menu.
- **PERFORMANCE**
 - Speed issues in getting historical data will be handled by implementing new widget in the portal which will provide access to data in minimal time possible for time period and data amount.

2.4 Citizens' Observatories Web Portal

The CITI-SENSE Citizens' Observatories Web Portal is a gateway to the products and services developed and used by the CITI-SENSE project. This includes web applications, smartphone apps, methods, open source codes, questionnaires, and serves as a forum for discussions and debate (Figure2-12).



What is CITI-SENSE Citizens' Observatories Toolbox?

The main goal of the Citizens' Observatories Toolbox (COT) developed in the CITI-SENSE project is to provide various tools with guidance for the future usage by citizens, scientists and interest groups, as well as commercial interest.

The CITI-SENSE COT includes any resources and guidance, procedures, software, hardware or services developed by CITI-SENSE that can be used to support citizens to participate in environmental monitoring and enable citizens to contribute to community based environmental decision making.

The CITI-SENSE Citizens Observatories Toolbox addresses the following components:

- Server side management of Sensors data and other types of Surveys data
- User applicability, using Mobile Apps and Web Portals
- Widgets and code-snippets
- Methods for generate data, access/download data and view/visualise data
- Data

Contact us to see how we can help you!

Widget name	Storage platform	Code link	Usage description and link
Real-time sensor value	WFS	http://citisense.uhopper.com/widgets/sensors/	http://citisense.uhopper.com/pilots/common/#Tabs-realtime
Historical sensor values	WFS	http://citisense.uhopper.com/widgets/sensors/query_sensor_statistics.js	http://citisense.uhopper.com/pilots/common/#Tabs-historic
Physical activity levels	WFS	http://citisense.uhopper.com/widgets/activities/	http://citisense.uhopper.com/pilots/barcelona/#Tabs-physical-activity

Surveys

In this page, we present different types of survey with questionnaire tools, developed and used within CITI-SENSE, including aim of the survey, target groups, where the survey implemented, where the survey data stored, how the data being visualized, etc.

Survey name	Aim of the survey	Target Groups	Where to find the survey	Where is the survey implemented	How is survey implemented
Outdoor AQ living questionnaire	To gauge the Level of knowledge of citizens and their interest for air quality in a respondent's urban environment	General citizens	Barcelona, Castellón, Edinburgh, Barcelona (Català)	Barcelona, Shanghai, Edinburgh	Web and smartphone application from UHopper, done on the Cloud/ios platform
			Barcelona (English)	Halls	

Figure 2-13 Web page Citizens' Observatories Web Portal

2.4.1 Summary of location reports

This report is mainly based on internal feedback from project members given during a consortium meeting where all the CITI-SENSE products were tested internally. In addition, 3 external people answered the questionnaire specifically about the Citizens' Observatories web portal. Even though we do not have much feedback, we can use them as indication of issues that needs to be addressed and how we can improve the product.

Table 2-4 Suggestion for improvements for the CITI-SENSE Citizens' Observatory Web Portal

Feedback
High complexity
Scope is too wide
The target audience is not well defined
Non functionality
Not organised
Not easy to navigate
Not easy to find what you want
Not final/operating yet
Consideration to security/privacy
Methods are a bit too complex

2.4.2 Report from product owner

Over the four years that the project operated, the co.citi-sense.eu portal has gone through several changes. These were often prompted by feedback from the consortium, the general public, and the portal owners themselves.

Initial feedback suggested changes to the look and feel of the site, and ultimately, this led to a completely new 'skin' being deployed. This changed its look dramatically, then focus shifted to content and structure. Over the final two years, incremental changes were made to the presentation of data.

This can be seen reflected in the changing face of the portal. The front page went from a more detailed, 'busy' look to a more graphically based, dynamic looking page with eye catching colours and dynamic content (see Figure 2-13 and 2-14).



Figure 2-14 Original look of page in 2013



Figure 2-15 Current look of portal main page 2016

Additional changes were made with the addition of videos, links to social media and especially the development of the project's outcome pages in the COT, or Citizen Observatories Toolbox.

Initially presented as a list of links, this was later expanded to include custom graphics, and a hot spot clickable image map that led to the various products. Each of the petals of the COT 'flower' could be clicked, linking to further pages of information on the various topics (Figure 2-15).

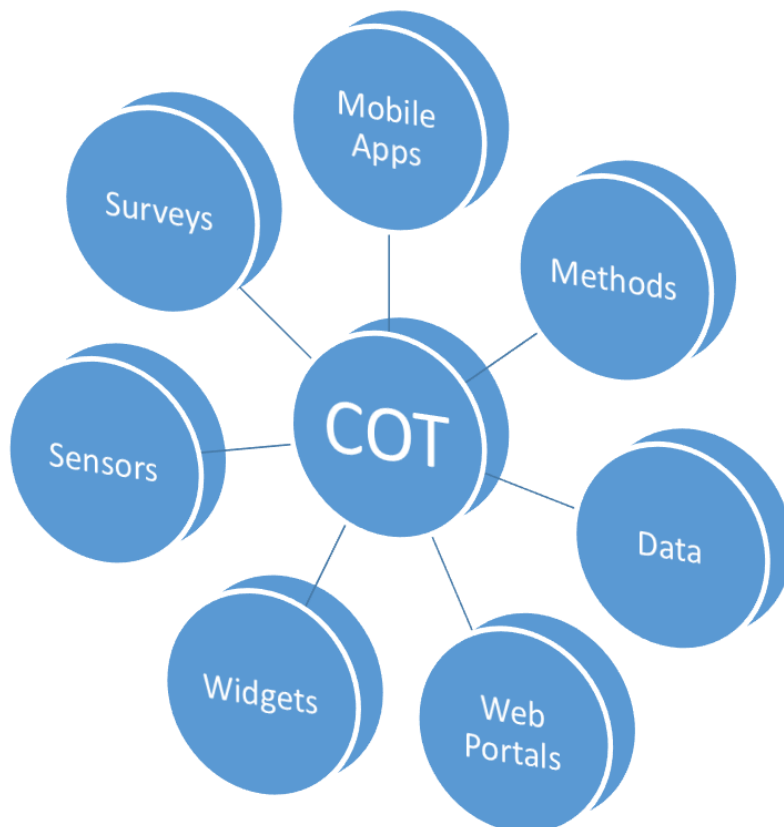


Figure 2-16 Citizens Observatory Toolbox flower

Consistent effort was put into the portal to ensure that it was as informative as possible and at the same time, looked good, with carefully managed content, only live links, and useful and relevant texts.

Even though the project has achieved its final period, small changes still occur on the portal, with the latest drive being the streamlining of menu items, to make finding material more intuitive for the users.

Based upon the feedback from the CITI-SENSE consortium members and external users, WP4 has done the following improvements for the CO web portal:

- Clearly described and highlight the COWP's goals within the module 'Citizens' Observatories of Air' on the front page, with the following: 'The CITI-SENSE Citizens' Observatories Central Web Portal is designed to enable citizens to not only have access to real-time environmental information provided by a wealth of sensors and sensor platforms, including Portable sensors and Static sensors, Mobile Apps and different types of Air pollution perception surveys, but also to provide a forum for discussion, debate and sharing of your own personal observations.'
- Defined and addressed the COWP's potential users in the module 'Who can use CITI-SENSE Citizens' Observatories Toolbox?' on the page 'Citizens' Observatories Toolbox', like this 'CITI-SENSE Citizens' Observatories Toolbox can be used by different stakeholders and end users, e.g., general citizens who is interested in air quality related environmental issues, environmental NGOs (Non-Governmental Organizations), authorities, industries, students, teachers, parents, school boards, etc., for different purpose, for example, research, urban planning, environmental sensing, education, citizens' observatories and citizen science related activities, etc.'
- To help users to find what they want, we created a module 'How to use CITI-SENSE Citizens' Observatories Toolbox?' and 'How to Assess CITI-SENSE Citizens' Observatories Toolbox?' on the page 'Citizens' Observatories Toolbox'.
- There is no direct data download functionality on the COWP. In the sub-page, 'Data,' within the 'Citizens' Observatories Toolbox' page, we only provide the link that users can view the outdoor air quality data visualization and environmental quality data visualization in public spaces. For access to the indoor air quality data, the user name and password are required.
- Within 'Citizens' Observatories Toolbox', there are seven major components categorised including 'Methods'. Currently, on the page 'Methods', we addressed seven major methodologies developed in the project. We are working on to simply the 'Methods' page and its seven subpages, but the page is public available, not closed.
- The COWP is operating now and we are checking all the typing errors, hyperlinks and other functionalities, restructuring and organizing the content better, and the COWP will be running and updating continually.
- We are working on the synergy with GEOSS via COWP as well.

3 Evaluation of products and services for School Indoor Quality

The aim of this Empowerment Initiative was to support citizen's participation by improving the physical indoor environment in schools. The results of this EI are described in D3.4.

The feedback for products and services used are mainly collected by the Ljubljana case study. It was carried out with regular meetings and interactions with the stakeholders during the school year, mostly when help was needed for preparation of students' research assignments. At the end of the school year final meetings were held with teachers involved.

3.1 Atmospheric sensors

This unit (Figure 3-1) is provided by Atmospheric Sensors Limited in Bedfordshire, UK, who is not a partner in the CITI-SENSE project, but collaborates closely with the CITI-SENSE partner Alphasense. It measures CO₂, CO, NO₂, O₃, PM₁, PM_{2.5}, PM₁₀, T, RH and noise and communicates with a server using GSM/GPRS the data being available online. The device also has a local storage and the data can be downloaded to a computer via USB.



Figure 3-1 Atmospheric sensor unit

3.1.1 Summary of location reports

The teachers and students found it interesting to be able to view near real time data and to use multiple sensor nodes deployed in the school. They felt the equipment was easy to install and it was positive that the units did not need any continuous maintenance to operate.

They see the potential of using these kinds of data and measurement units in different school projects and they experienced that results lead to actual measures and gave them knowledge about how to ventilate efficiently. It was positive that they could measure at least CO₂ and PM with this unit from Atmospheric Sensors.

The negative comments we received was that it was difficult for the young elementary students to download data. In addition, neither the elementary students nor the teachers were used to work with raw data sets and did not find sufficient visualization tools available in the CITI-SENSE portal. Since the data was not accurate enough, it also meant that they could not compare the results to regulative values or trust that each separate device could be compared. The sensor devices need power supply and this was felt as a drawback, in addition to missing parameters as VOC.

These are the suggested improvements from users and location officers:

- Make a more finalized product
- Develop a battery operated version
- Include VOC in the device (Volatile organic compounds to measure odour and scents)
- Have more accurate measurements
- The devices should be pre-calibrated
- Develop more user friendly data visualization and download functionality

3.2 Netatmo



3-2 Netatmo Weather station

This air quality unit is provided by Netatmo, a French company specializing on connected objects. Netatmo is not a partner in the CITI-SENSE project. The basic Netatmo weather station comprises of an indoor module and an outdoor module. Additional indoor modules can be installed. This device provides temperature, pressure, humidity, noise and CO₂ measurements. In addition, a Netatmo phone app displays outdoor air pollution data from the nearest official monitoring station as well as weather forecast. The modules communicate with the main indoor unit through radio signals, and the main indoor unit sends the data online thru Wi-Fi.

3.2.1 Summary of location reports

The Netatmo unit was used in the Ljubljana case study as an off-the shelf sensor unit. The feedback for the Netatmo is mainly positive. It felt nice to have a function to actually "see" air quality without visiting a web page, since the unit comes with a button on top of the device that lights the led green, yellow or red according to what is measured. This lowers the intention to use the product every day.

The device was easy to install and use and felt as a final product. Users enjoyed the available online graphs, the download options and that they could use a phone app with widgets to view the unit's measurements.

The only negative comment reported was that this device needed Wi-Fi connection and this could be an issue in some schools. The feedback for improvement was therefore to include another data transfer option in addition.

3.3 Radon sensors

CITI-SENSE partner Obeo provided sensors to measure radon (Figure 3-3). The sensor measures radon with a silicon semi-conductor, detecting alpha particles from radon decay. The unit has external AC/DC adapter for 230VAC use. The data is collected and stored in memory and is uploaded to server over GSM cellular network at intervals of twelve hours.



Figure 3-3 Radon sensor unit

3.3.1 Summary of location reports

The radon sensor unit was positive in the sense that it could be used to indicate whether there is a radon problem and in which rooms. This led to further measurements with professional devices. They were also able to move the units around the school and investigate what is happening without external help.

The positive feedback also included the functionality for seeing data online as graphs in near real-time mode.

The negative remarks were mainly about the quality of data and they could therefore not compare the results to regulative values. The suggestion for improvement was therefore to develop a unit with more accurate data, especially in low concentration range, and to provide pre-calibrated devices, also with battery for easier placement of the equipment in the school buildings.

3.3.2 Report from product owner

The unit is developed to be easy to use and the online graphs are there to give fast feedback to the user.

The functionality to show data in near real time is useful only as an indication. Especially low concentrations will be inaccurate. This type of radon measurement is intended to be used with longer time interval, typical 60 days average to give an accurate measurement.

We are currently investigating the possibility to develop a similar unit with battery for more convenient use.

4 Evaluation of products and services for Public Spaces

The aim of this Empowerment Initiative is to support citizens' participation in the public management of urban planning related to outdoor public places.

4.1 Environmental Monitoring Toolkit in Public Spaces

The environmental monitoring toolkit is a product developed in this project in collaboration with Tecnalia, NILU and SINTEF. It consists of a smartphone with different applications, an external microphone and a weather sensors unit (Kestrel) (Figure 4-1).



Figure 4-1 Environmental monitoring toolkit

The purpose of the toolkit is to engage citizens on the observation of public spaces and on the assessment of its quality.

4.1.1 Summary of location reports

The feedback from citizens and city authorities was collected during specific feedback workshops and in-depth interviews in Vitoria-Gasteiz, Spain, and in other cities.

This report is based on content from D3.2 "Pilot study evaluation and protocol for phase 2" and D3.4 "Evaluation of the performance of the user cases".

Positive feedback

The whole toolkit was in general seen as a positive and useful tool to evaluate public spaces and to notice elements in the environment that could be easily unseen. The smartphone application and the Kestrel sensor were among other described as light, smart and appealing. The city authorities stated that it could be an asset to get information about public spaces. The toolkit was seen as technologically advanced and useful and they would not change any parts of it (Figure 4-2).

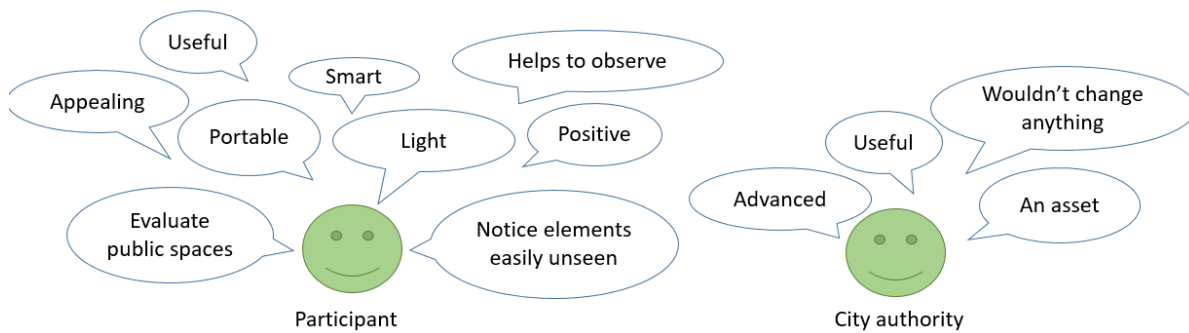


Figure 4-2 Positive feedback

Negative feedback

This toolkit is built up by a variety of components, both hardware components, such as the Kestrel weather sensor to measure wind speed, relative humidity and temperature, and software components and smartphone apps like the CityNoise for detecting noise events from the external microphone, SensorLog for reading the Bluetooth stream with the measured values from the Kestrel sensor, SensApp to store the measurements on a server and the SENSE-IT-NOW application included with the CivicFlow questionnaire that works as a graphical user interface for all collected data. In addition to the sensor units and the applications on the smart phone, there are two different web servers involved; one for storing the questionnaire data and one for storing the sensor measurements.

The negative feedback is thus categorised into the following components, each category listing specific issues and problems reported by the users (Table 4-1):

Table 4-1 Negative feedback for the Environmental Monitoring Toolkit in Public Spaces

Component	Issue category	Feedback
SENSE-IT-NOW	Communication between CivicFlow and SENSE-IT-NOW	Sometimes the answers from questionnaire not found. There were some thermal comfort missed.
	Delay of data	
	Layout	Questionnaire does not fit in screen. Buttons on noise popup is too small.
	Bugs & Errors	App crashes sometimes. If you minimize the app it restarts. Shows previous data. The noise popups slow down app. Email option not working
Kestrel sensors SensorLog/SensApp	Communication with sensor unit	Connection fails.
	Bugs & Errors	Messages about connection do not appear. URL for server storage is occasionally lost.
External mic & CityNoise		Delay of noise alert.
CivicFlow questionnaire	Layout	Results-button is not clearly visible. Screen not fluent when navigating. Not correctly fit in screen.

		Graphs of results do not fit the screen. Filling in blanks sometimes displace items. Option for before/after screen disappears.
	Content	Questionnaire should be shorter or divided into several parts The questionnaire is too long.
	Bugs & Errors	E-mail is asked multiple times. Data from previous sessions are shown. Keyboard pops up when not necessary.
Toolkit general	Devices	Not comfortable to collect data using two devices instead of one.
	Battery	Citizensense kit and the app are strong battery consumers.

Suggested improvements

The next table shows users ideas, suggestions and feedback about improving the Environmental monitoring toolkit for public spaces.

Table 4-2 Suggestion for improvements for the Environmental Monitoring Toolkit in Public Spaces

Environmental monitoring toolkit for public spaces

Software improvements to link both devices properly

Should be user friendly and more intuitive for different age groups including elderly

Mark to know what parts of the questionnaire are already filled

Develop a detailed manual including instructions about the experience

Automatically close questionnaire when finished answering

Automatically show the results when session ends

GPS and data transfer should be turned on automatically

It would be good if one could use this for reporting also other things than just environmental conditions.

4.1.2 Report from product owners

The toolkit could be improved by making the components more flexible to answer to specific needs of different urban spaces, in terms of being able to measure or evaluate a broader set of potentially critical variables identified in each situation.

There is a clear limitation to the use of the developed products, since currently citizens cannot use it with any smartphone they choose, so they cannot use their own smartphone. To assure the

technical quality and robustness of the measured acoustic data, the acoustic app was decided to be calibrated for a specific smartphone model, meaning that its use cannot be generalized. Moreover, the need of using an additional thermal sensor steps up this limitation. The product, as it is currently designed, requires that a smartphone is provided as part of the kit to participants. The product can be improved creating a new version, a more universal one, hence keeping the technical quality fit for purpose.

In general one lesson learned is to think smaller when it comes to what a smart phone app developed using HTML5/JavaScript actually should do and do more of the work on the server side. A smart phone app works better and gives better user experience with smaller tasks and less complexity.

5 Summary/Conclusion

There are several conclusions and lessons learned that can be taken from the collected feedback from people testing the products and services used in the CITI-SENSE project.

The primary aim of every product needs to be to assure that the equipment has a reliable and stable communication chain between all the elements from sensors to platform, platform to products and to the end user. The second goal is to provide trustworthy measurements that can be compared with regulative values.

Currently the small sensor units do not have the same quality of the measurements as larger reference instruments (but this may in the future). Therefore, developers of graphical user interfaces should take this into consideration and look into new ways of presenting air quality data from data sources with uncertain quality.

Another suggestion regarding presentation of data is to include other external data sources. This will extend the users' potential of the product and can also better engage citizens to participate in citizens' observatory activities. In addition, the common feedback about nearly all products and services was that the visualization tools should have different possibilities to view the data i) real time ii) historical and iii) options to study more details about the measurements.

Using technical equipment to do actual measurements regarding air quality both outdoor and indoor, adds something positive to the process. It makes it interesting and it feels meaningful to contribute personally to a global case. It also encourage the user to think beyond the specific task and gives them ideas about what the measurements can be used for and in other areas the data can have an effect on.

For a product or service developer, this means that including different usage areas should be considered as an extension to already existing solutions. It can be targeting specific groups, like developing customized information boards to kindergartens to be used for daily planning of activities, or information to house buyers/house sellers in interesting areas.

The extensive experience of developing and using software and hardware products in the CITI-SENSE project can be a major resource for both sensor developers and software developers to avoid these problems in the future and to get ideas of new or improved products.