D2.4: Report on co-creation of services

WP2 – Analysis and requirements

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1 Summary

In deliverable 2.4, we describe the user research and the different co-creation activities that were carried out in the hackAIR project in the first half of the project (M1-M18).

The hackAIR platform is developed through a co-creation process with users and different stakeholders. The co-creation process takes place from the beginning of the hackAIR project until the final delivery and usage of the hackAIR platform/toolkit. Figure 1 gives a general overview of the different phases of the hackAIR co-creation process, mapped upon each respective stage of the hackAIR project. Users are involved through all phases of the innovation process, starting from an exploration of the context of the users, followed by an idea and concept development phase up to the iterative development of the platform and eventually the exploitation strategy.

This deliverable describes the user research carried out in the first half of the hackAIR project, in the phases prior to the development of the platform (phase 1). The second part of the hackAIR co-creation process (phase 2), where users will be iteratively involved in the development and roll-out of the hackAIR platform, is part of WP7 and is not discussed in this deliverable.
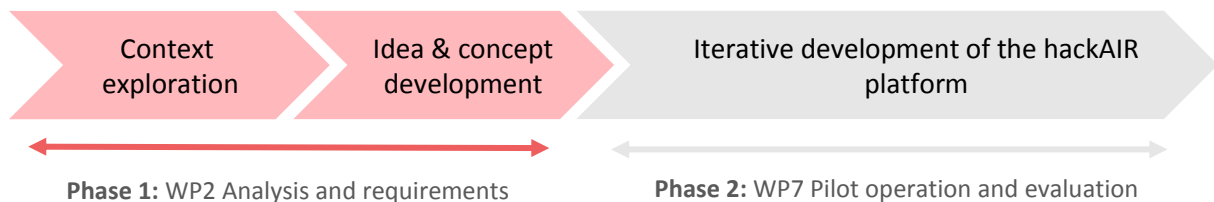
Context exploration	Idea & concept development	Iterative development of the hackAIR platform
Phase 1: WP2 Analysis and requirements		**Phase 2:** WP7 Pilot operation and evaluation

Figure 1: The hackAIR co-creation process

Two phases of co-creation workshops were organized in the pilot countries. The first phase in M6 of the project, as well as the second in M10 and M11 of the project. The goal of these workshops was to explore the context of users and to involve users in the idea and concept development phase of the project. They guarantee that the users' voice is being heard, and their ideas and feedback are integrated in the to-be-developed hackAIR platform.

This deliverable builds further upon D2.1 (Stakeholders co-creation methodology definition) that described the co-creation methodology. In D2.2 (User and technical requirement analysis), an overview of the first set of user and technical requirements was presented. They were identified after iterative discussions and interactions with project partners and after the first co-creation workshops with end users. In the second phase of co-creation workshops, these requirements were discussed in-depth, after which they were again validated with project partners and external stakeholders. The end-product of the co-creation process in WP2 is a final set of user and technical requirements about the hackAIR platform.

This deliverable is structured as follows. We start with a description of the applied methodology and the workshop set-up. After this, an overview is given of the findings of workshop phase I and workshop phase II. Finally, a refined list of requirements is presented as conclusions as they integrate the lessons learned during the co-creation process.

2 Methodology: Co-creation

This section describes the set-up of the co-creation research. Two phases of co-creation workshops were organized in both pilot locations (organised by BUND in Berlin, Germany and NILU in Oslo/Norway) to explore potential end users' needs, values and expectations with regards to hackAIR. We chose to organize co-creation workshops as they enable the collection of a vast amount of qualitative data from multiple respondents during a short time period and they lead to a deeper level of meaning and sense-making than quantitative methods. For more information on the concept of co-creation and how to organize co-creation workshops, we refer to D2.1.

Figure 2 gives an overview of the co-creation workshop flow that was defined for hackAIR. Two workshop phases were defined. The first phase focused on concept exploration, while the second was geared towards idea and concept development.

The goal of the first workshop phase was to validate different user scenarios and generate and evaluate relevant ideas and concepts related to hackAIR. These workshops resulted in a first identification of the user requirements and the creation of a first set of mock ups.

The second workshop phase explored the user requirements in-depth and discussed possible functionalities and features of the hackAIR application. The developed mock-ups acted as a discussion starter here. The outcome of the second workshop phase is a final set of user requirements.
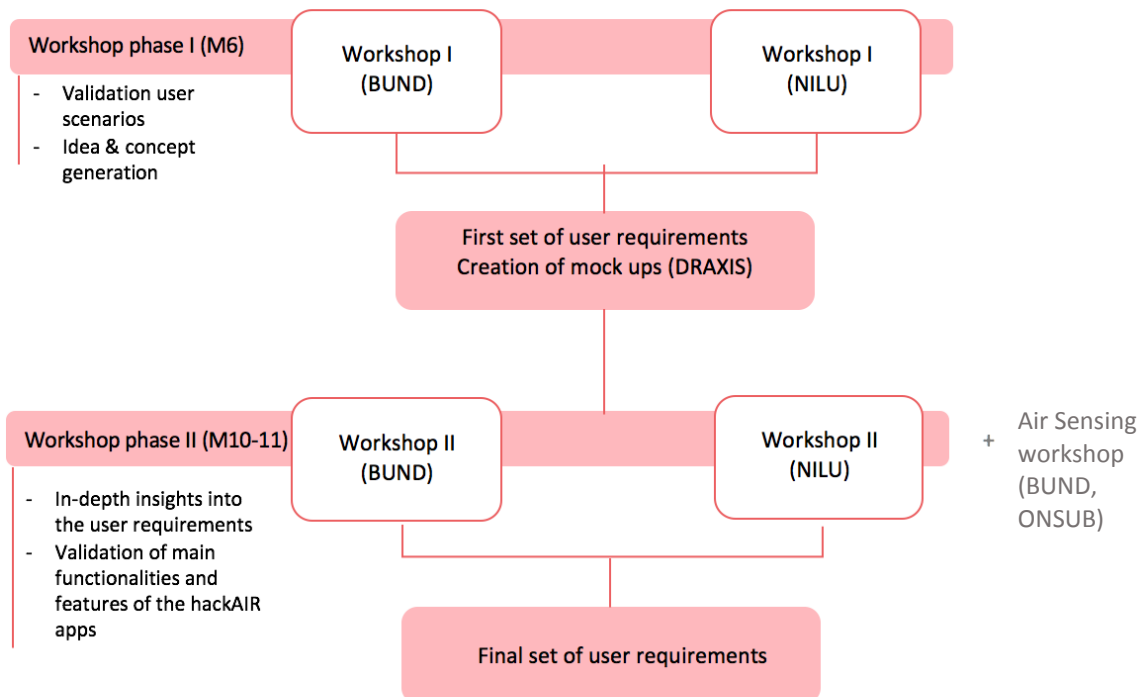

Figure 2: The hackAIR co-creation workshop flow

The workshop methodology and materials were developed by VUB, and the actual workshops took place in the two pilot locations and were led by representatives of BUND (for Germany) and NILU (for Norway).

Besides the workshops organized with potential end users of the hackAIR platform by BUND and NILU, BUND and ONSUB also organized the **Air Sensing workshop** on 18/11/2016 in Berlin with stakeholders from the hackAIR Air Sensing Network. The Air Sensing Network is the virtual community for organisations and initiatives working on participatory sensing on air quality. This Network was set up by hackAIR and is one of the outcomes of the work of WP8.
The goal of this meeting was to bring together those interested in exchanging lessons learned on how to both bring forward participatory sensing of air pollution and facilitate exchange between different initiatives in this field. During this meeting, a co-creation exercise was included to get some feedback on the hackAIR mock-ups. The same mock-ups were also evaluated with the hackAIR internal partners during the consortium meeting.

2.1 The hackAIR co-creation workshops: set-up

2.1.1 Set-up workshop phase I

The workshop consisted of four parts. The first two parts of the workshops focused on general users' practices and expectations with regards to measuring and retrieving air quality information, whereas the last two parts focused on the hackAIR platform in particular. Generative co-creation tools and techniques were used in order to help the participants to give input.

Overview of the workshop sections:

1. Current practices and experiences with regards to measuring and retrieving air quality information

   To start the conversation and get to know the participants, we started with some **open questions** about current experiences and practices with regards to measuring air quality and/or retrieving air quality information. Questions were asked for example on how and when they get informed about air quality and what sources (apps, websites) they use for this.

2. Motivations and expectations for using air quality platforms/applications

   Open questions were asked to explore the motivations for (not) using air quality services. Furthermore, a short exercise was included in which the participants were asked to evaluate three existing air quality applications (Plume air report[1], CityAir[2], Breezometer[3]) in order to get some first ideas on what they like and dislike about the existing air quality apps.

3. The hackAIR user scenarios

   In the context of WP2 T2.2, two hackAIR user scenarios were created (see D2.2) that describe the possible interactions of different types of end users with the hackAIR platform. These scenarios were used in the workshop as they helped the workshop participants in getting an idea of the possibilities of the hackAIR platform and as such acted as a discussion starter for what users expect

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[1] Website: https://plumelabs.com/en
[2] Website: http://cityairapp.com
[3] Website: https://breezometer.com

from the hackAIR platform. The scenarios were divided into simplified smaller parts or scenes that describe only a few delineated actions a user can perform with the hackAIR platform in a certain usage situation. Teams of users were asked to evaluate the scene descriptions using a standardized form (e.g. 'what would you keep/change/delete?'). Findings were discussed in groups and additional open questions were asked. An example of a question is whether users would be interested in using such a platform, when, where, how, on which devices…and if they would be interested in using hackAIR.

4. hackAIR low-fidelity prototyping

Low-fidelity prototypes of the hackAIR applications were created together with the workshop participants to get a first glimpse into how users think, and how they would like the user interface of the hackAIR applications to look like. Each team was asked to focus on one of the two scenarios they had to evaluate.

The full topic list can be found in Annex 1. The hackAIR user scenarios can be found in Annex 2.

2.1.2 Set-up workshop phase II

The second workshop consisted of five parts. In the first three parts of the workshop, the main hackAIR functionalities and features were presented, discussed and evaluated. Specific attention was given to the gamification features. As probes, we used the interface mock-ups of the hackAIR app and the gamification wireframes created by DRAXIS. Further, in this workshop privacy expectations with regards to the hackAIR platform were explored (as part of the PIA process) and a first exploration of the open hardware sensor measurements was executed. Generative co-creation tools and techniques were used in order to help the participants give input.

Overview of the workshop sections:

1. Validation of the main functionalities of the hackAIR platform

The DRAXIS team created different mock-ups of the hackAIR mobile and web application interfaces to illustrate the different functionalities of the hackAIR apps and how the different screens could look like. These were presented to the participants. To gather the feedback, a role-playing exercise was performed. Groups of users were assigned a certain role (e.g. environmental activist) with which they had to empathize and evaluate the mock-ups from that point of view (Is all the info they need in there? Does the app help in reaching their goals?). In another exercise, the teams were asked to discuss what they would keep, change and delete.

2. Validation of the gamification dynamics

Gamification elements will be included in the web and mobile app to trigger user contributions and user engagement. In this part of the workshop the gamification dynamics were explored, including which exact gamification features users are interested in. For this, we made use of the wireframes provided by DRAXIS. Teams of participants were asked to indicate on the wireframes what they liked and disliked. Findings were discussed in groups, and additional open questions were asked to gather additional in-depth information on the gaming dynamics.

3. Validation of the (possible) features of the hackAIR platform

Besides discussing and evaluating the main functionalities, these mock-ups also facilitated the translation of these main functionalities into a more elaborate set of specific hackAIR features. The different features were discussed. To help the discussion, we created a set of 33 cards of which each card visualised a possible feature. The participants were asked to group together all features into 3 categories: features that were a must-have (1), features that would be nice-to-have (2) and features that were not at all a must-have (3). Additional blank cards were provided to the participant on which they could draw a feature they thought was missing.

4. Privacy

As part of the hackAIR Privacy Impact Assessment (T2.3), first insights were gathered with regards to users' current privacy concerns and practices for the hackAIR services. For this purpose, two exercises were created. In a first exercise, the participants were given a list of different types of personal information. They had to indicate which types of personal information they have no problem with sharing, which information they would probably share and which types of information they would not share under any conditions when creating a hackAIR profile. In a second exercise, we explored different factors that can determine whether or not a website or service is deemed trustworthy to handle your personal data. A list with eleven factors was created (based on a literature review) and the participants were asked to rank these factors.

5. Open hardware

Open questions were asked to explore the participants' interest contributing to the hackAIR platform with sensor data.

The full topic list can be found in Annex 3. The hackAIR mock-ups can be found in Annex 4, the gamification wireframes in Annex 5.

2.1.3 Practical organization of the workshops

The co-creation workshops took place in the two pilot countries and were organized with help of the local pilot partners BUND and NILU. As the head offices of BUND and NILU are in respectively **Berlin and Oslo**, the co-creation workshops took place there. VUB developed the co-creation workshop method and materials. BUND and NILU recruited the research participants and organized and led the co-creation workshops.

Since the workshops took place in Germany and Norway, the languages that were used during the workshops were German and Norwegian, respectively. We chose to organize the workshops in the mother tongue of the participants in order to make them feel as comfortable as possible to express their opinions and ideas. This means that an extra effort was made by BUND and NILU to translate workshop materials into German and Norwegian, as well as in the reporting of the research results in English.

The **duration** of all workshops was **two hours**. These workshops were run by one (for the BUND workshops) or two (for the NILU workshops) moderators who introduced the discussion topics. An additional person was present during all workshops to observe and take notes.

Before the start of the workshop, all participants signed an **informed consent form** that explained the research goal and method, the risks and benefits of participation and included a privacy and

confidentiality statement. It was first orally explained to the participants what informed consent is. Afterwards they were given the necessary time to carefully read and sign the document.

The workshops were **audio-recorded** for the sole purpose of processing the workshop discussions. The recording devices were only switched on after making the participants aware of the recording devices in the room and the 'research-only' purpose of the recording.
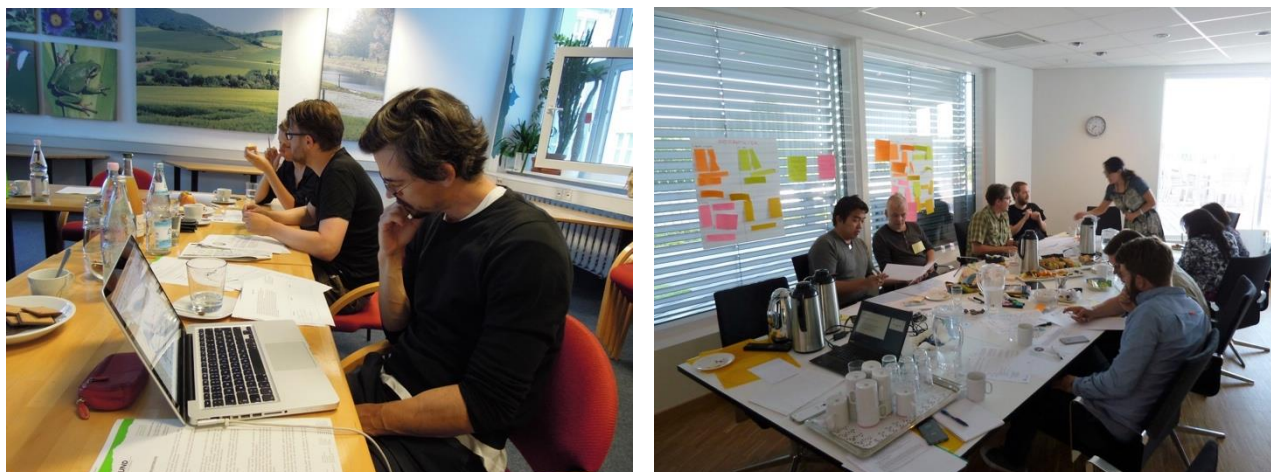

Figure 3: Illustration workshop BUND (left) and NILU (right)

Potential end users of the hackAIR platform were invited to participate in the co-creation workshops. In internal discussions within the consortium, multiple categories of end users relevant for hackAIR have been mapped (see D2.2). For the recruitment of participants for the co-creation workshops, focus was put upon the following two categories:

- **People with a health problem** (e.g., respiratory diseases), as well as certain groups of **people with a health risk** related to air pollution (e.g. parents of young children, people exercising outdoors) or people related to or close to a person with a health problem or risk (e.g. the mother of a child with asthma).
- **Environmentally aware citizens**, ranging from people with a general environmental or health interest to members of environmental organizations.

Table 1 gives an overview of the organized workshops and the workshop participants.

	NILU		BUND	
Workshop	I	II	I	II
Date	June 21, 2016	Oct 19, 2016	June 27, 2016	Nov 10, 2016
# participants	8	7	4	9
Age range	Min: 31 Max: 48	Min: 20 Max: 48	Min: 25 Max: 35	Min: 18 Max: 64

Table 1: Overview workshop participants

An effort was made to recruit the same participants for both two workshop phases. Within each workshop, we also tried to have a maximal spread in respondents regarding socio-demographic characteristics (gender, age, work situation etc.). The participants were recruited via mailings, social media and the personal networks of the researchers from BUND and NILU.

2.2 The Air Sensing workshop

During the **Air Sensing Workshop** organized by BUND and ONSUB on November 18 2016 in Berlin, 23 stakeholders from the hackAIR Air Sensing Network participated. 5 people were present in person in Berlin, while the remaining 18 stakeholders participated in the meeting via an online conference tool. The goal of this meeting was to exchange information and best practices with regards to initiatives on the participatory sensing of air pollution. During this meeting, the hackAIR mock-ups as developed by DRAXIS were presented to get some direct feedback on the hackAIR application in development. To gather the feedback, a similar exercise as in workshop phase II was executed. Every workshop participant was asked to evaluate the designs based on the following four questions:

- *What are your first impressions?*
- *What would you keep?*
- *What would you change?*
- *What would you delete?*

Those participants present in person, wrote down their answers on cards, and the people following the meeting online sent their answers via an online messaging tool.

3 Results

In this section, we describe the results of the co-creation workshops.

The workshops organized by BUND and NILU followed an identical topic list. As the results of the workshops organized by NILU and BUND were very similar, we will not present the findings separately. We start with describing the results for workshop phase I, after which we discuss workshop phase II. The evaluations made of the hackAIR mock-ups during the Air Sensing Workshop are also integrated in the discussion of workshop phase II.

3.1 Workshop phase I

3.1.1 Current practices and experiences with regards to measuring and retrieving air quality information

We started with some open questions about current experiences and practices the participants had with regards to measuring air quality and/or retrieving air quality information.

3.1.1.1 Retrieving air quality information

How do they get informed about air quality?
The participants reported to get informed about air quality in their city via **websites** and **mobile apps**. The websites they visit are mostly the ones operated by the environmental protection agencies, or other websites that display data of official (government) measuring stations. The mobile apps they use also mainly show official measurements.

When do they search for information about air quality?
The participants search for air quality data on different occasions. **A main motivation or occasion for people to search for air quality data is when they know or sense that the air quality is bad.**
The following moments were mentioned during the workshops:
- When they sense that the air is dry or bad
- When they walk/bike (or plan a walk or bike ride) along roads with heavy traffic
- When the media writes about the bad air quality in their city
- When performing (or planning to perform) outdoor activities
- In the morning
- Before conducting a trip to/from work

How often they look for air quality information, depends mainly on one factor: **the location where they live and how bad the air quality generally is there**. A couple of respondents for example had lived in China, where they became informed on air quality on a very regular basis to plan their day. The participants living in Oslo or Berlin rarely checked on a daily basis, rather preferring to do so a couple of times a week.

What type of air quality information do they look for?
The respondents not only search for the (local) air quality levels in their cities, but also for more context and background information on air quality. The respondents look for the following types of air quality information:
- **(Local) air quality data:** What are the air quality levels in my city? And how are they compared to other cities?

- **The sources of air pollution**: What is it that makes the air quality so bad? What are the main sources of air pollution? What is the share of different means of transport (i.e. cars, airplanes, local public transport) in air pollution? And what about fossil fuels and combustibles, the burning of wood …?
- **General information on air quality**: What does 'air quality' or air pollution really *mean*? What is bad and good air quality?
- **The effect of air pollution on health**: Is air pollution dangerous? What are the short- and long-term effects on our health?
- **Solutions:** What can we do to improve air quality?
- **Specific information**: if air quality is mentioned in the media people want to find out more about the topics raised is the media as they normally do not give extensive information about it.

Most experiences workshop participants have with regards to retrieving air quality information are negative. They cited numerous reasons for this.
- There is a **lack of information**: They refer to the granularity of the air quality data. There is no precise air quality information available for every location. There is a high need for more fine-grained air quality data.
- **Background information is missing**. The respondents report that often they are not able to make sense of the air quality data. What do the air quality levels mean? What does this mean for my outdoor behaviour today?
- **Wrong/confusing air quality information**: There often is a mismatch between what the media say about the air quality in a city, and what the (official) air quality measuring institutions show on their websites or apps.
- **Availability of the information**: Air quality data are not always readily available.
- **Presentation of the information:** The websites operated by the environmental protection agencies and other websites with official (government) measurements are often out-dated and present the measurements ('bulky information') in a not very user-friendly way.

> To conclude, when it comes to retrieving air quality information, the participants noted to **miss** the following:
> - More fine-grained air quality data
> - Air quality data and information that is understandable for lay people
> - Clear instructions as to what you should do when the air quality is bad

3.1.1.2 Measuring air quality

Only a limited number of workshop participants have measured air quality themselves at least once. This was mostly for work-related reasons or because of their participation in a research project on air quality. In the workshop organized by NILU, 3 participants stated to have measured air quality themselves, and in the workshop organized by BUND 1 participant had done this. They measured air quality by means of an air quality measuring device (the P-Trak ultrafine particle counter for indoor air

quality, technology bought in China) or by means of COTS-based systems (the Bucket Brigade in the US, where a bucket is used to trap air into a bag[4]).

Although the measurements are considered quite **accurate**, measuring air quality is considered quite **difficult**. It is difficult to standardize air quality equipment and challenging to build your own measuring device. Handheld devices are also considered quite **expensive** and sometimes inconvenient to use, e.g. to transport the handheld measuring devices in the carriage box.
Despite these inconveniences, the participants expressed an interest in contributing to air quality measurements.

To conclude, when it comes to using or developing individual hardware sensors, the participants reported the following:
- Executing air quality measurement is perceived as being difficult
- Building own measuring devices is perceived as very challenging
- Measuring devices are perceived as being expensive

3.1.2 Motivations and expectations for using air quality services

We started with some open questions on the participants' motivations for (not) using air quality services. Besides having a general **environmental consciousness and concern**, the main motivator for having an interest in retrieving air quality information is a general concern with regards to **the effect of air pollution on health.** This motivation to start retrieving air quality data and information was more pronounced for people living in cities or areas with known pollution issues, as they are more likely to be exposed to the negative effects of air pollution on their personal health. They want to **know the main causes** of air pollution, what they and the government can do to improve air quality on the causes of air pollution and which possible mitigation measures can be taken.
When air quality is discussed or mentioned **in the media**, this also acts as a motivator to search for (local) air quality information. People want to know the air quality levels in their city compared to other cities, and what politicians' ambitions are with regards to reducing air pollution.
However, when the personal health is not affected and when air quality is not a topic in the news, interest in retrieving air quality information is quite low for some respondents.

To get some insights on what the participants like and dislike about the existing air quality apps, and what their general expectations are towards such applications, a short exercise was included in the workshop. Three existing air quality applications were presented to the (Plume air report, CityAir, Breezometer) which they had to evaluate based on four questions:
- *What are your first impressions of the platform/application?*
- *What do you like about this platform/application?*
- *What do you dislike about the platform/application?*
- *What is lacking in this platform/application?*

Answers were written down on sticky notes, and then discussed in group.

Generally, the following factors were deemed very important for air quality services:

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[4] For more information on the Bucket Brigade and their air sampling method, see http://www.pbs.org/pov/fenceline/the-bucket-brigade/

- **The design**: The participants highly value a '**good looking**' user interface and a **simple** design**.** A simple design means that there is no overload of data (at first sight) and that the data and information is presented in a way that is understandable for everybody.
- **The sources of the data**: When evaluating the apps, a common remark was that they did not understand what the air quality level was based on. What are the sources of the displayed data? How should the air quality index be understood? The participants want to know where the data come from and how to make sense of the data (what is good and bad air quality?).
- **Real-time, historical land forecast data**: Not only real-time air quality data is important, but the participants stated they also want to see how the air quality evolves over time.
- **Recommendations on activities**: The participants liked the fact that the applications Breezometer and Plume air report linked the air quality with recommendations for outdoor activities. A variety of personalized recommendations can be a trigger to use an air quality app.

Further, for the CityAir app, they liked the **social** aspect of the app, where you can see other users' contributions on a map. This can motivate users to use the app and contribute with data. What they disliked about the CityAir app, was **a missing link between users' air quality perceptions and the actual air quality**. The subjective data should somehow be paired with the objective of 'real' air quality measurements.

Finally, a general remark made about all the applications, is that there is a **low motivation to keep on using the applications**. It is rather unclear for the participants how and for what they can keep on using the (sometimes limited) air quality information.

To conclude, when it comes to motivations and uses of air quality applications, the participants reported the following:
- It is difficult to be kept motivated to use air quality apps
- Comparisons between cities or locations is an important feature
- It is important that the applications have a user-friendly design
- Personalised recommendations are perceived as something motivating
- The users want detailed information on the measurements (sources, impact, behavioural changes, …)
- Information spread via the media is an important stimulator to start being interested in air quality

3.1.3 Feedback on the hackAIR platform

In the last part of the workshop, the idea behind the hackAIR platform was presented to the users. As there were no mock-ups of the hackAIR platform available yet, we made use of the hackAIR user scenarios (see D2.2) that were divided into simplified smaller parts or scenes that describe only a few delineated actions a user can perform with the hackAIR platform in a certain usage situation. Teams of users were asked to evaluate the scene descriptions based on three questions:
- *What would you **keep** in this scenario?*
- *What would you **change**?*
- *What would you **delete**?*

Findings were discussed in groups and additional open questions were asked.

Generally, the following aspects of the platform were received well:

- **The participants express a need for quasi-real-time, understandable and easily accessible data on PM levels in the city.** The more fine-grained the data is, the better. City-level data are not sufficient for people living in a big city. A big current frustration is that no (quasi-) real-time data is available for every location in a city (e.g., people living quite far from a measuring station).

- The **personalized notifications and recommendations** were received very well. However, users should be able to indicate in the user settings which types of notifications/recommendations they want to receive and how to receive the notifications/recommendations (e.g., SMS, push notification via the app). They would like to get suggestions about what to do when the air quality is bad, how they can protect themselves from air pollution and how they can help in reducing air pollution. The recommendations should also not prohibit behaviour, but give alternatives instead. In case of a high level of PM, the application should for example not recommend users to not go outside, but instead suggest an alternative route.

- **The community/social factor** is also considered important and motivating. It is interesting to see if there are others near you who are also using the app and/or contributing with data. Users want to be able to see who in the neighbourhood is also using the app and/or contributing with measurements. Physical encounters with people using hackAIR is a good motivator to stay engaged.

- The **creation of a profile** should be voluntary, as some users did not express an interest in this (but they would like to use hackAIR to access air quality info). When creating a profile, basic non-login information should be enough (name, email). Adding additional personal information to the profile should always be voluntary, to avoid **privacy** issues and concerns.

- In general, the integration of game-elements is perceived very well. **Gamification** features, among others, can help in motivate the users in **keep on using** the hackAIR platform (rather than being a motivation to start using hackAIR). They are popular for various reasons:
  - It is considered **motivating** to use the apps and creates an additional incentive to contribute with data.
  - It is **fun.**
  - Points, badges and other tools give **recognition** for contributions. This feeling of recognition is considered as very important.
  - The 'competition' with others can create a **sense of belonging.** The social factor is important ('How well are my friends or the people in my neighbourhood performing?')

  However, it is important to choose the right gaming approach. For example, based on the level of interest/engagement, the gaming tasks could become more complex. Alternatively, the platform could give more points if the measurement is really relevant, i.e. in a new place or in real time (instead of uploaded in the evening).

The participants are especially interested in using hackAIR in **a mobile setting**: on the way to work, friends or other destinations, on holiday etc. Therefore, they are **especially interested in using the hackAIR mobile app** on their smartphone or tablet. There is less interest in using the web app.

Further, users would like to receive **feedback** on the relevance of their contribution. Questions include: Was the quality of my measurements sufficient? How important is (the total share of) my contributions with regards to the display/granularity of the air quality levels in my city?

SMS alerts or notifications were perceived as unnecessary. They prefer push notifications via the mobile application more than SMS notifications, and fear that SMS messages could become expensive when travelling.

There was a little bit of scepticism towards the 'submit pictures of the sky' feature of the application, as the participants didn't really understand how this could help in measuring air quality. The idea and method behind this feature should thus be clearly stated, in order to motivate users to take pictures of the sky.

> To conclude, when it comes to feedback on the hackAIR platform, the participants reported the following:
> - Participants want quasi real-time data on a finer grained level than city level
> - Personalized recommendations should not prohibit behaviour, but should give alternatives
> - Creating communities who also meet in real life would be a stimulating factor
> - Participants are concerned about their privacy
> - Gamification elements are perceived as being positive to keep on using the platform
> - A mobile app is very important
> - Participants that add data to the platform want feedback on the quality of the delivered data
> - Participants would like to receive feedback about the relevance of their contribution

3.2 Workshop phase II

3.2.1 Evaluation of the mock-ups and the main functionalities of hackAIR

In the first part of the workshop, mock-ups of the hackAIR mobile and web applications were presented to the users to gather feedback on the different functionalities of the hackAIR platform and on the design of the platform. See Annex 4 for an overview of the created mock-ups.

Teams of users were asked to discuss the mock-ups and write down the following in a template:
- *What are your first impressions?*
- *What would you keep?*
- *What would you change?*
- *What would you delete?*

Findings were discussed in groups and additional open questions were asked.

Their **first impressions** on the mock-ups were the following:
- Generally, the participants liked the design. The **user interface looked good** and the **colours are very nice**.

- **The home page of the web application is considered overwhelming.** Too much information is displayed on the home page, which can come across as confusing and complicated.
- There is some **confusion on the air quality index in the web application**. Some participants were unsure if this is the index for the whole city or only for part of the city. There also was some confusion on whether or not users' subjective perception of the air quality ('submit your feeling') also influences the air quality index.
- It was not clear what all the **symbols** mean **on the air quality maps**. A legend with the meaning of the symbols is missing.

Table 2 gives an overview of what the participants said they would <u>keep, change and delete</u>.

Keep	- Air quality information - The participants very much liked the fact that, at first glance, you can receive a quick indication of air quality, both in the mobile and web app ('Perfect' – 'Good' – 'Neutral' – 'Bad' – 'Awful'). - The immediate display of concrete **air quality values here & now** (the air quality index) is necessary. - They liked the fact that not only real-time air quality data are displayed, but also **historical data and they would have liked hackair to provide forecast data too**. - The **notifications** with air quality information were accepted very well. However, they are considered especially relevant when threshold values are exceeded. **The heat map** was considered a 'must keep'-feature. - They liked the **granularity of the map** and the possibility to zoom in to see street- or neighbourhood level information. - The participants also liked the fact that the heat map gives the possibility **to choose which air quality sources you want to see displayed on the map** ('sensors', 'photos', 'open data', 'peoples' feelings', 'my sensors', 'my photos'). - The **'My contributions' overview** on the profile page is considered a keeper. **Behavioural tips** are also important. In the mock-ups recommendations were given for different activity possibilities (e.g. 'You can go out for a run safely'). The participants like to receive suggestions on how to adjust outdoor behaviour to the air quality.
Change	- There were mixed feelings about the '**Submit your feeling'** feature. - There exists **low trust in people's subjective perception**. It is considered 'too subjective' and the correlation with the actual air quality is questioned. What if the perception of air quality is not correct? And what about contributions from kids? Are they trustworthy?

- The relevance of this feature is not really understood. What is the added value to the map and open or sensor data? They relevance of this feature should thus clearly be communicated.
- The **slogan** "How do you feel the air today?" is not very clear.
- In the mock-up of the mobile app that shows how to submit your feeling of the air, the 'submit' button should be in a different shape than the 'feeling' buttons.
- The first impression of the home page of the web application was that it was too overwhelming. The **home page** and the information on it should thus be simpler. This could be achieved by only displaying quick and simple air quality information on the home page, and adding the more detailed information on other pages or tabs.
- **Air quality forecast data**: If hackAIR would provide forecast data **data for the next hours** would be interesting as this is relevant for planned outdoor activities later in the day.
- **Air quality notifications** are considered especially relevant when threshold values are exceeded. Some participants preferred to only receive a push notification about air quality warnings (when air pollution is too high). They do not want daily reminders when it is not necessary.
- The heat map:
- The map provides no **explanation about the meaning of the symbols and of the meaning of the colours** (e.g. is red life-threatening or just a bit uncomfortable?). A legend that explains the meaning of the symbols and colours should be included.
- Some participants do not see the **added value of pictures** on the map.
- **The contribution indicator** (e.g. 'you have contributed with 15% of the data and you are the 2nd best contributor') in its current form can be demotivating. Is % the ideal measure of participation? New users of the platform or users who don't contribute often might for example just have a 0,0001% indicator, which is not motivating. Other mechanisms that give users feedback on the relevance of their contribution should be considered.
- The creation of a **profile**:
- Some participants were wondering if **only individuals** can have a profile. What about for example schools? For environmental awareness raising, schools and kindergartens are good target groups. To recruit schools and/or kindergartens, it would be interesting for them to be able to register as an organization.
- Some participants stated they would like to have the possibility to contribute **anonymously** or submit data without having to create a profile. Concerns were for example raised with regards to others finding out where you live, if you would submit daily sky pictures from where you live.
- **Social features:** in the mock-up of the web app**,** the bottom part of the homepage displays the actions and contributions of other users of the hackAIR platform. However, these 'social features' are not considered very relevant for the

	participants. It is thus good that the focus is put on the air quality info, and the social features are placed at the bottom of the page. • The integration of **social media buttons** (e.g. Facebook) raised some mixed opinions. The majority, however, perceived these as unnecessary because of a lack of added value.
Delete	• On the profile page on the '**personal info**' tab, quite some personal information is asked for and displayed. Not everybody is willing to provide all this personal data. Providing this data should thus not be obligatory. Some participants also expressed that they would like to be able to **set their profile information as private**. • The 'friend' function is not needed (stressful) → add a **'follow'** feature instead

Table 2: Evaluation of the mock-ups

In addition, the participants also reported to be <u>missing</u> some functionalities:
- An overview with **trends and air quality statistics** would be nice. What are the air pollution trends throughout the day? And what are typical values for each day of the week or month, or for the morning or afternoon? One respondent raised the idea to also display **historic air quality information on the heath map** to be able to spot the 'dangerous' parts of town.
- **More frequent air quality updates** (e.g. every hour instead of every day)
- The threshold values for concentration are displayed nowhere.
- There is no clear indication of the **sources of the air quality data**.
- An indication of the uncertainty for the air quality at the user's location and the area of validity.
- **Background information on air quality (t**his is not in the mock-ups right now, but this will be included in hackAIR applications): Some participants expressed that they would like to have more background information on air quality and pollution, and what they can do to tackle air pollution.
- **A newsfeed on air quality**, among others with news, science updates or political happenings.
- A **sharing function** to directly share own measurements and other contributions on Facebook for example.
- **Route suggestions**: it would be useful to have a route planner with information on alternative routes with less pollution.
- **Tutorials** that give an introduction into the platform for new users, on how to set up a sensor.

3.2.2 Evaluation of the gamification dynamics

As game elements will be an essential part of the hackAIR platform in order to keep users engaged, a separate part of the co-creation workshop was dedicated to explore the gamification dynamics in detail. Specific wireframes were created by DRAXIS as a tool to discuss the different gamification features. See Annex 5 for an overview of the created wireframes.

The wireframes showed examples of:

- Quick missions (e.g. 'snap a picture of the sky') and rewards and recognitions users can get after finishing a mission
- Notifications about poor air
- Suggestions for actions users can do to help in reducing air pollution
- Sending and receiving challenges to and from other users
- Leader boards, overview of achievements and rewards

In general, the participants were **not very fond of the gamification** approach of the wireframes. The main reason why they would use the app is to believe that their contributions are of use for others or that they could lead to political change. **They think rewards should be connected to achievements with a 'real impact' (e.g. receiving a badge for planting a tree, points for using the bike).**
The participants would like to receive quick missions and suggestions and badges, but they are less keen on collecting points and receiving challenges.

- **Collecting points** as rewards was **not popular** for two reasons. First, there is the perception that people can cheat by e.g. taking a lot of pictures from the same location just to get more points. Second, points are no real bonus and are considered rather meaningless. The participants rather want feedback on how their contributions helped society for example. Points won't motivate in the long run, but 'real impact' will.
- The **badges** on the other hand are a bit more popular, as they give feedback when contributing to the platform. Badges visualize that you contribute to the community and that what you do is important and useful. Ideally badges should thus connect achievements to real impacts. The participants like the **'achievement' screen** where an overview is given of the collected badges.
- The **challenges** were not popular, both receiving challenges as well as challenging a friend. They could be fun for some people, but it is unclear on how the challenges can keep the long-term interest of the user. In general, friendly completion with others is not wished for. If challenges are included, they shouldn't be too difficult or high (e.g. uploading 100MB of data for example requires already quite a big effort).
- Receiving a **quick mission** to contribute something to the platform (e.g. a picture of the sky) and **suggestions** with actions on how to help reduce air pollution and help to protect oneself were very popular. Quick missions can be used to link the air quality with behavioural change. E.g. Alert! The air quality is bad. Here's what you can do: (1) Take an alternative route, (2) Don't exercise if not necessary, (3) Turn off any potentially polluting items. Quick missions can also be used to nudge users to explore (new) features of the app.

Another idea raised was to receive some kind of reward (e.g. stars, badge…) for the subjective accuracy of contributions compared to nearby measurements.

3.2.3 Validation of the specific features of hackAIR

The mock-ups helped in discussing the main functionalities of the hackAIR platform. To evaluate a range of more specific (possible) hackAIR features, a set of 33 cards with a variety of possible features was created. The participants were asked to group together all features into 3 groups: (1) features that are

a must-have, (2) features that would be nice-to-have and (3) features that are not a must-have (3). See Annex 6 for an overview of all the cards.

Table 3 gives an overview the features that are considered a must have, nice to have and no must have.

Must have	- Air quality information: - Access **real-time, historical and forecast data** about air quality <u>in your city</u> - Comment: Why not neighbourhood? District? - In the BUND workshop, historical data is considered a nice-to-have and not a must-have feature - Spatial view of the air quality (**heat map**) **Timeline** with the air quality evolutions **Learn more** about air quality, the sources of air pollution the effect of air pollution on health - Receive <u>app notifications</u> on my mobile device with **air quality updates** - SMS and email notification not popular - App notifications preferably only to warn if air pollution is too high - Behavioural change/limit exposure to air pollution: - Read **tips** on what you can do to reduce air pollution - Read **tips** on how to limit your exposure to air pollution - Receive **notifications with recommendations** on how to limit your exposure to pollutants (e.g. alternative biking route) - Receive **notifications with recommendations** on what to do when the air quality is bad (e.g., "Don't use your car today"). - Check **which outdoor activities** I should or shouldn't be doing today → Clear need for information on how to change behaviour and limit exposure to air pollution **Message board:** Ask questions to other users and discuss relevant topics **Contribute** to air quality measurements by uploading the data of my air quality **sensor** - Sensor data is much more popular than contributing with photos of feelings about the air **Receive feedback** on the quality of the data I send - Adjust **the privacy setting** of your profile and personal information
Nice to have	- Contribute to air quality measurements by taking and uploading pictures of the sky through the mobile app - It could be that the workshop participants don't fully understand how taking pictures of the sky can be used to contribute to air quality measurements. This should thus be clearly communicated to the users. - Check how my submitted perception of the air quality relates to the actual air quality

	• Create a profile • Compare the air quality in your city with other cities 　　○ Mixed opinions: Other cities' air quality is less important than the cities the participants live, work and/or study. • Gamification: Unlock badges
No must have	• Receive <u>email notifications</u> with air quality updates • Receive <u>SMS notifications</u> with air quality updates • Login with my social media account • Submit my perception of the atmosphere by entering a rating on the air quality for a specific location and check other users' perception. • Gamification: 　　○ Earn points for contributions 　　○ See ranking compared to others • Contribute to air quality measurements by taking and uploading pictures of the sky on social media using the hackAIR hashtag

Table 3: Evaluation of the hackAIR features

Opinions were mixed about the following features:
- Connect ('**Friend**') with other hackAIR users. Some participants indicated they would rather 'follow' other users instead of friending them.
- See who of my friends from social media are using hackAIR so I can connect with them in hackAIR.
- See who in my neighbourhood is also using hackAIR. Some participants said they would rather see <u>how many</u> **people in their neighbourhood** are also using hackAIR, but not who exactly.
- Check the contributions of other users.
- See what the level of my contribution is.

3.2.4 Privacy

To gather some first insights on privacy concerns and practices or the hackAIR services, two exercises were created. In a first exercise, users' willingness to share personal data with the hackAIR services was assessed. In a second exercise, different factors that can determine whether or not a website or service is deemed trustworthy to handle your personal data were explored. Both were individual exercises that the participants completed on a paper form.

3.2.4.1 Willingness to share personal data

The following question was asked:

In the hackAIR platform, you will be able to add extra personal information about yourself in order to receive better personalized notifications. Which types of personal information you have no problem with sharing, which information will you maybe share and which types of information will you not share?

The following categories of personal data were provided (in this order):

- Telephone number
- Address (Street and number)
- Address (city)
- Job
- Political preference
- Name and surname
- Date of birth
- Gender
- Interests (e.g. outdoor sports)
- Email address
- Health information (e.g. respiratory problems, heart diseases, pregnancy)

Table 4 gives an overview of the types of personal data users have no problem with sharing, which information they would probably not share and which types of information they would not share under any condition. However, for five types of personal data the meanings were very mixed (see last column).

YES	MAYBE	NO	MIXED OPINIONS
City	Health info	Telephone	Full address
Gender		Political preference	Email
Interests			Job
			Name and surname
			Date of birth

Table 4: Willingness to share personal data with hackAIR

The topic of privacy came up spontaneously during all workshops even before the first privacy exercise. Many of the participants were rather privacy-concerned, and not just willing to give any type of personal data without knowing why this is useful. For example, the participants are only willing to provide health information if this leads to a valuable and relevant service in return (e.g. notifications on poor air for someone with asthma). There is a high wish for control over personal data.

3.2.4.2 Factors that influence trust

The following question was asked:

Which factors determine whether you find a website or service trustworthy to handle your personal data? Make a ranking from 1 (most important) to 11 (least important).

The following factors were provided (in this order):

- The brand
- Popularity/fame of the brand
- Friends who also use the website/service

- Messages in the media about the website/service
- The presence of a privacy policy
- Transparency about the personal data collected (which data + what it is used for)
- Whether or not your data is shared with third parties
- The look & feel of the website/service
- The clarity of the website (how easy is it to find everything?)
- The presence of specific logos or certificates (e.g. European Union, trust certificates…)
- The possibility to contact someone (via live chat, e-mail, address organization…)

Table 5 gives an overview of the average ranking. An interesting finding is that the first three factors are related to privacy, factor 4 to 7 is related to the design of a service, and factor 8 to 11 to image and popularity of the 'brand'. This again proves that privacy and transparency and control over personal data is very important for potential users of hackAIR.

Privacy	1. Transparency about the personal data collected 2. The presence of a privacy policy 3. Whether or not your data is shared with third parties
Design	4. The look & feel of the website/service 5. The possibility to contact someone (via live chat, e-mail, …) 6. The clarity of the website 7. The presence of specific logos or certificates
Brand	8. Messages in the media about the website/service 9. The brand 10. Friends who also use the website/service 11. Popularity/fame of the brand

Table 5: Factors that influence trust

3.2.5 Open hardware

We finished the co-creation workshop with some quick open questions to explore the participants' interest contributing to the hackAIR platform with sensor data.

There definitely is an **interest in measuring air quality with a sensor**. The participants want to measure and keep track of air quality themselves. Also, the sensor is an interesting tool to **teach science to kids** and give a practical demonstration of how air quality can be measured.

Very important is that the sensor is **easy to use and to install**. The organization of **workshops** to assemble the sensors together with others is popular, as not everybody has the knowledge on how to do this. Furthermore, the **open architecture** of hackAIR is considered very important, so interested citizens can use the air quality sensor of their choice.

There is interest in paying for a sensor, but this of course depends on the price. In the workshop of BUND, the price of 20-30 Euro was considered acceptable.

4 Conclusion: the final list of user requirements

In Deliverable 2.2 (M7), an overview of the first set of user and technical requirements was presented. This set of requirements originates from users' current practices and expectations (practices with regard to retrieving air quality information and expectations with regards to the hackAIR platform) and takes into account the technical feasibility with regards to the different hackAIR components. They were identified after iterative discussions and interactions with project partners and after the first co-creation workshops with end users. These user requirements were then explored in-depth in workshop phase II and the user findings were then discussed again with the hackAIR consortium during the third hackAIR plenary meeting (November 24-25 2016, Brussels). This led to a refined list of requirements (see below). New or changed requirements (compared to the first list of requirements) are indicated with an '*'. This list was mailed to all consortium partners, and each partner was asked to indicate for each requirement whether they *Agree (A), Disagree (D)* or if they think the requirement should *be discussed further (TBD).*

The following sections will indicate for every requirement whether partners Agree (A) or Disagree (D) with the user or technical requirements, or if they think the requirement should be discussed further (TBD). Further discussions on the TBD topics are planned to be taken up during the next consortium meeting(s).

4.1 The hackAIR platform requirements

4.1.1 Requirements on the air quality information

The hackAIR platform should contain the following types of air quality (AQ) information:

Nr	Requirement	DRAXIS	CERTH	NILU	BUND	ONSUB
R1	The platform should contain quasi-real-time, understandable and easily accessible data on PM levels in the city.	A(gree)	A	A	A	A
	R1a: Only particulate matter data will be displayed ($PM_{2.5}$ and PM_{10}). Other pollutants will not be taken into account.	A	A	A	D(isagree) /TBD[5]	A
	R1b: Quasi-real-time data is data that is maximum 24 hours old. An effort should be made to provide more frequent AQ updates than every 24 hours.	A	A	TBD	A	A
	R1c: Quasi-real-time data should be displayed for a variety of cities ('here & now'). Data should at least be available for the following cities: Oslo (Norway), Berlin (Germany), Brussels (Belgium) and Athens (Greece). *[6]	A	A	TBD	A	TBD

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[5] TBD is the abbreviation for To Be Defined. Partners selected this answer if they thought not enough information about hackAIR of technical components were available to clearly answer this question.
[6] Air Quality data on other cities in Norway will be visible via the data fusion map.

		R1d: The platform should contain fine-grained AQ data. City-level data are not sufficient for people living in a big city. The resolution of the maps will be at least 5km.	A	A	A	A	A
		R1e: The information presented needs to be understandable for lay people. This could be achieved by working with simple colour or numerical scales and by avoiding the use technical terms.	A	A	A	A	A
		R1f: The source(s) of the data should be clearly stated (e.g., the local Environmental Protection Agency).	A	A	A	A	A
		R1g: The platform should give information on the reliability of the data. *	TBD	A	A	A	A
R2	The platform should contain a contextualization of the AQ data or possibility for comparison.		A	A	/[7]	/	A
		R2a: Users should be able to compare the AQ in their city with other locations: How is the AQ in my city compared to other cities? * [8]	A	A	TBD	TBD	TBD
		R2b: The platform should also contain historical data. *[9]	A	A	A	TBD	A
		R2c: Users should be able to see the evolution of the AQ (Historical vs. real-time): How has the AQ in my city changed over time? How is the AQ now compared to the past (yesterday, 1 year ago…)? *	A	A	A	D	A
		R2d: Users should be able to see how many days the maximum PM level was exceeded the last year for the different cities. *	/	A	TBD	A/TBD	A
R3	The platform should contain background information/educational package on AQ.		A	A	/	/	/
		R3a: The platform should give information on what "air quality"/" air pollution" really means.	A	A	A	A	A
		R3b: The platform should give information on what is bad/good AQ.	A	A	A	A	A

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[7] / means that the partner didn't provide an answer to this question (most often because they found themselves not knowlegable to do.

[8] Originally, next to city-level comparisons, neighbourhood-level comparisons were also part of this requirement. However, as pointed out, comparisons at a neighbourhood level will not be possible.

[9] Originally this requirement stated that the platform should contain historical and forecast data. However, as pointed out, hackAIR will not provide forecast data.

		DRAXIS	CERTH	NILU	BUND	ONSUB
	R3c: The platform should give information on how to make sense of the data. How to 'judge' AQ and what factors to take into account?	A	A	A	A	A
	R3d: The platform should give information on the sources of air pollution. What is it that can make AQ so bad? What is the effect of different types of transport on air pollution? And domestic wood burning? …	A	A	A	A	TBD
	R3e: The platform should give general information about the potential effects of air pollution on health.[10]	A	A	TBD	A	TBD
R4	The platform should contain information on how to reduce air pollution.	A	A	/	/	TBD
	R4a: Users should be informed on how to improve AQ. Give recommendations on alternative ways of living and keeping levels of air pollution at a minimum. These recommendations should not prohibit behaviour, but give alternative ways to trigger behavioural change.	A	A	A	A	A
	R4b: Users should be informed on how they can limit their exposure to pollutants. Give recommendations on what to do when the AQ is bad.	A	A	A	A	A
R5	The platform should contain information on why it is useful for people to retrieve AQ data. It should be clearly stated how and for what purpose people can use AQ data. Currently the motivation to keep on using such a platform after a first interest is not clear. E.g., for what type of activities is it useful to check the AQ regularly (outdoor sports, eating outside…).	A	A	A	A/D	TBD

4.1.2 Requirements on the user applications

Nr	Requirement	DRAXIS	CERTH	NILU	BUND	ONSUB
R6	Users should be able to use the hackAIR services via a web app and via a mobile app.*	TBD	A	A	A	A
R7	Users with Android and Apple phones should be able to use the hackAIR app.*	A	A	A	A	A
R8	Users should be able to download the application on their smartphone and on their tablet.	A	A	A	A	A

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[10] The health-related information should be rather general, as hackAIR cannot give medical advice.

Nr.	Requirement					
R9	The web app should be able to be consulted via all web browsers on different operating systems (Mac & Windows).	A	A	A	A	A
R10	The web application should have a mobile friendly interface, so users can easily access it on their mobile phone as well.	A	A	A	A	A
R11	Third parties should be able to create a personalized web application (= the community portal) that they can integrate in their own platform.	A	A	TBD	A/ TBD	TBD
R12	Some light customization of the community portal should be possible (e.g., logo, colour scheme).	/	A	D	A/ TBD	TBD
R13	Basic features of the community portal have to be installed on the client's server and will be offered for free. Advanced features or services will be provided as SaaS and will be offered at a cost.	A	A	TBD	TBD	TBD
R14	The community portals should stay self-sustainable after the hackAIR project ends.	A	A	A	A/TBD	TBD
R15	The project site of the platform is in English. The pilot site of the platform and the user applications should at least be available in the language of the pilot countries (Norwegian, German).	A	A	A	A	A
R16	The platform will be developed as open source software, and uploaded to source repositories as GitHub and distributed for free, under the MIT (or AGPL v3) open source license.[11]	A	TBD	A	A	A

4.1.3 Requirements on the interface / design

Nr.	Requirement	DRAXIS	CERTH	NILU	BUND	ONSUB
R17	The GUI of the web and mobile app should be *simple* and give *direct access to AQ measurements*. On the homepage, only basic AQ data visualisations should be displayed. Users can navigate through the apps for more detailed information. *	A	A	A	TBD	A
R18	The web and mobile app should have a clear visualisation of the AQ.	A	A	/	A	A
	R18a: The web and mobile app should contain a spatially continuous map of the AQ levels in the city. *	A	A	A	TBD	A
	R18b: Users should be able to change the granularity of the map (zoom in – out). *	A	A	A	A	A
	R18c: Users should be able to filter the display of the different AQ sources on the map. * - Sensors - Photos	A	A	A	A	A

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[11] Some modules might depend on third-party software that is not open source.

	- Open data						
	- Peoples' feelings						
	- My sensors						
	- My photos						
	R18d: The web and mobile app should contain a timeline display of the AQ levels and evolutions. *	A	A	A	A/TBD	A	
R19	The homepage of the hackAIR web app should provide different types of information to certain hackAIR users (data providers or only data users). *	A	A	A	A	A	
	R19a: Users that contribute with data should directly see on top of the page where they can upload sky pictures, perceptions of the AQ and open hardware measurements.	TBD	A	A	A/TBD	TBD	
	R19b: Users that only use hackAIR to access AQ information should directly see on top of the page the hackAIR AQ data, background information on AQ and information on how they can reduce air pollution.	TBD	A	A	A/ TBD	TBD	
R20	Users should see the AQ data and visualisations in the web and mobile app automatically in their time zone. *	A	A	A	A	A	

4.2 Requirements on the features

4.2.1 Gamification

Nr.	Requirement	DRAXIS	CERTH	NILU	BUND	ONSUB
R21	Multiple engagement strategies and tactics should be embedded in the web and mobile app to motivate users to keep on contributing. *	A	A	TBD	A	TBD
R22	Game-elements should give users recognition and feedback on their contributions to the platform and as such motivate users to keep on contributing. *	A	A	TBD	A	TBD
R23	Rewards should be connected to achievements with a real impact or value. *	TBD	A	A	A	TBD
R24	Notifications, quick missions and individual challenges should encourage users to change their behaviour when the AQ is bad. *	A	A	TBD	A	TBD
R25	Notifications, quick missions and individual challenges should nudge users to explore (new) features of the apps. *	TBD	A	TBD	A	TBD
R26	A point-based reward system and (public) ranking should not be used. *	TBD	A	A	A/TBD	TBD
R27	Users should be able to 'unlock' badges that visualize users' contribution to the platform. *	TBD	A	TBD	A/D	TBD
R27	Users' achievements should be displayed on their profile page. *	A	A	TBD	A/D	TBD

R28	Based on the level of engagement with the platform, the missions and challenges should become more complex. *	TBD	A	TBD	TBD	TBD

In general, the gamification dynamics should be worked out further to define more specific requirements.

4.2.2 Communication and interaction features

Nr.	Requirement	DRAXIS	CERTH	NILU	BUND	ONSUB
R29	A message board should allow users to discuss relevant topics, ask questions to the hackAIR community and receive feedback and help from other users.	A	A	A	A/TBD	TBD
R30	Users should be able to see how many people in their neighbourhood are also using the app and/or contributing with measurements. *	A	A	TBD	A	A
R31	Users should be able to connect with other hackAIR users. They can choose to 'follow' other people. *	A	A	TBD	A	TBD

An important new requirement that should be discussed further is the role of hackAIR admin users or scientists to inform and explain measurements to the participants.

We should also discuss if it is a good idea to roll out the platform directly on city level, or if it would be better for community building to select specific neighbourhoods.

4.2.3 Notifications and recommendations

Nr.	Requirement	DRAXIS	CERTH	NILU	BUND	ONSUB
R32	Users should be able to indicate in the user setting whether or not they want to receive (personalized) notifications and recommendations, based on the personal information they have provided. Notifications alert users on the air quality. Recommendations give activity and behaviour tips. *	A	A	A	A	A
R33	Notification and recommendations should be short text messages which users can quickly read. *	A	A	A	A	TBD
R34	Users can choose which types of notifications they want to receive. *[12]	A	A	/	A	A
	R34a: The platform should give notifications when the AQ is bad. *	A	A	A	A	A
	R34b: The platform should give notifications when the AQ is perfect. *	TBD	A	A	D	D
R35	Users can choose which types of recommendations they want to receive. *	A	A	/	/	TBD

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[12] User research pointed out that most users don't want to receive daily air quality notifications. They would rather only get a notification if the air quality is bad, so they know when to take precautions. However, it was decided to also send notifications if the air quality is very good, so we can also bring positive news to the users and reinforce a positive feeling of accomplishment.

	R35a: The platform should give recommendations on what outdoor activities not to do when the AQ is bad.	A	A	A	A	TBD
	R35b: The platform should give recommendations on what outdoor activities to do when the AQ is perfect. *	A	A	A	TBD	TBD
	R35c: The platform should give recommendations on how to reduce air pollution. *	A	A	A	A	TBD
	R35d: The platform should give recommendations on how to limit the exposure to pollutants.	A	A	A	TBD	TBD
R36	Users can choose how to receive the notifications/recommendations.	A	A	/	A	A
	R36a: The platform should enable push notifications in the mobile app.	A	A	A	A	A
	R36b: The platform should enable email notifications.	A	A	A	A/TBD	A
R37	Users are able to set the frequency of notifications (e.g., every morning).	A	A	TBD	A	A
R38	Users should also receive notifications when the mobile application is not opened. The application should thus run in the background. *	D	TBD	TBD	A	A
R39	The recommendations should be linked with different types of outdoor activities (e.g., different types of sports, walking, eating outside...). Users can initially select which are their preferred activities in order to get recommendations related to their preferences. *	A	A	A	A	TBD
R40	Users should get feedback on how their contributions to the platform and changes in behaviour can contribute towards a cleaner air. (E.g., how does my action (e.g., not driving today) contribute to the common good? 10% fewer cars today is how much less pollution?)	D	TBD	TBD	TBD	TBD

4.2.4 Registration and profile management

Nr.	Requirement	DRAXIS	CERTH	NILU	BUND	ONSUB
R41	Users of the hackAIR platform can register and create a hackAIR account.	A	A	A	A	A
R42	The hackAIR platform should clearly state for users why it is useful to register. *	A	A	A	A	A
R43	Users of the platform can create a profile that displays personal information and their activity and achievements within the hackAIR platform.	A	A	A	A	TBD
R44	The creation of a profile is voluntary. It is not necessary/mandatory to register to access the AQ information.	A	A	A	A	TBD
R45	Only basic login information should be mandatory for registration (user name, password, email). *	A	A	A	A	A

R46	During registration, all extra fields for the different types of personal data (besides user name and email) should be displayed but not required. *	A	A	A	A/TBD	TBD
R47	The hackAIR platform should clearly state why it is useful for users to provide the different types of personal data (e.g. by means of a question mark with more information next to the field in the registration form). *	A	A	A	A	A
R48	At a later moment than registration, users should be asked again to provide personal information in order to receive personalized notification and recommendations. *	A	A	D	TBD	A
R49	As health data is sensitive data, the users should not be asked to provide different types of health data, but they should be asked whether they want to receive health related recommendations.*	A	A	A	A	A
R50	Multiple login possibilities should be offered (email, social media login).	A	A	A	D	A
R51	hackAIR should enable users to modify and/or delete personal information at any time ('The right to be forgotten').	A	A	A	A	A

4.2.5 Contribute with measurements

Nr.	Requirement	DRAXIS	CERTH	NILU	BUND	ONSUB
R52	Users should be able to contribute with geo-tagged and time-stamped sky pictures that they can submit via the hackAIR mobile app.	A	A	A	A	A
	R52a: It should be clearly communicated to the users how taking pictures of the sky can be used to contribute to air quality measurements. The relevance of this method should be clearly stated. *	A	A	A	A	A
	R52b: While taking a sky picture with the hackAIR app, users should get real-time feedback and guidelines in order to make a good /usable picture. *	TBD	A	A	A	A
R53	Users should be able to contribute by uploading geo-tagged and time-stamped sky pictures on Flickr using the official hackAIR hashtags. * (in the project meeting in November 2016 it was decided that this feature will not be developed)	A	TBD	A	A	A
R54	Clear guidelines should be given to users who wish to contribute with pictures on how to take the pictures (e.g., angle), what filters can and cannot be used, when they can take pictures (e.g., not too many clouds, not too early in the morning) …	A	A	A	A	A
R55	Users should be able to contribute with open hardware measurements from COTS based sensors, commercially dust sensors or the hackAIR standalone	A	A	A	A	A

		DRAXIS	CERTH	NILU	BUND	ONSUB
	BLE node, by submitting the data to the hackAIR platform.					
R56	Users should be able to upload how he/she perceives the air quality in their surroundings, by entering a rating on the air quality for a specific location.	A	A	A	D/TBD	A
R57	The platform should give an indication on places where there is a lack of measurements to motivate users to measure on those locations.	A	A	A	TBD/A	TBD
R58	Users should get feedback on the relevance and quality of their contribution. * Was the quality of the measurements sufficient? How important is (the total share of) my contributions with regards to the display/granularity of the AQ levels in my city? With regards to the subjective perception of the AQ for a specific location: how does the perceived AQ relates to the actual AQ?	TBD	A	A	A	A
	R58a: Users should get feedback immediately after they contributed with data, e.g. by means of a notification.	A	A	A	TBD	TBD
R59	The platform should contain detailed guidelines and tutorials explaining the different ways users can contribute with measurements. *	A	A	A	A	A

4.3 Requirements on open hardware

Nr.	Requirement	DRAXIS	CERTH	NILU	BUND	ONSUB
R60	Users should be able to make use of multiple open hardware solutions for monitoring AQ*	A	A	A	TBD	A
	R60a: Users should be able to make use of commercial off-the-shelf (COTS) based AQ monitoring nodes.	A	A	A	A	TBD
	R60b: Users should be able to make use of commercially available Arduino dust monitoring nodes.	A	A	A	A	A
	R60c: Users should be able to make use of a standalone hackAIR monitoring node (a programmable System-on-Chip (PSoC) based air quality monitoring node (BLEAir).	A	A	A	A	A
R61	Clear and easy instructions on how to build/set-up the hackAIR AQ sensors should be given.	A	A	A	A	A
	R61a: A manual should be written with a step-by-step explanation on how to set up the hackAIR AQ sensors. *	A	A	A	A	A
	R61b: A demonstration or how-to video should be created on how to set up the hackAIR AQ sensors. *	A	A	A	A	TBD
	R61c: A Q&A section should be written with extra information on common questions and errors. *	A	A	A	A	A

		DRAXIS	CERTH	NILU	BUND	ONSUB
	R61d: Users should be able to contact someone if they have extra questions with regards to the set-up of their hackAIR AQ sensor (e.g. contact email address).	A	A	A	A/TBD	A
R62	**The sensors need to be flexible and convenient in use and placement** (battery life, sensitivity to weather conditions…).	A	A	A	A	A
	R62a: A hackAIR case for the hackAIR sensors should be made. Users can buy this case or 3D print it themselves. *	A	A	A	TBD	A
	R62b: The hackAIR sensors should be able to operate and have power without a cable connection (battery, solar system…). *	A	A	A	TBD	A
R63	The prices of the open hardware solutions should be affordable.	A	A	A	A	A
R64	Mobile sensors will need to interact (e.g., via LED) to tell the users to upload their data to the platform.	D	A	A	TBD	A
R65	The platform should know where the sensor is located (GPS, but also outside on street side or backyard site, which floor of the building,…).	A	A	TBD	A/TBD	A
R66	The Arduino sensors don't automatically capture location, so the user should be asked to specify the location. *	A	A	A	A	A
R67	The sensor should send measurement data with a time stamp.	A	A	A	A	A
R68	Different cities reside in different time zones, so hardware sensors should be aware of that (or the cloud).	A	A	A	A	A

It is also important to decide what the channels will be to buy sensors (a web shop, a real shop, ecological organizations, …)

4.4 Requirements on privacy

Nr.	Requirement	DRAXIS	CERTH	NILU	BUND	ONSUB
R69	The hackAIR platform should be designed and constructed in a way to avoid or minimize the amount of personal data processed (privacy by design). It is important to identify privacy issues from the start so privacy protection measures can be incorporated into the overall design. *	A	A	A	A	A
R70	The privacy settings should be set by default at the highest level. *	A	A	A	A	TBD
R71	Elaborate privacy settings should be integrated. hackAIR should give users the option to choose which personal data they would like to set as private or as public. *	TBD	A	A	A/TBD	A
R72	Users always have to be able to change their data sharing permissions over time as the context or their privacy needs change. *	A	A	A	A	A

R73	Users should be informed about what features they can or cannot use when their profile is set as public or private. *	A	A	A	A	A
R74	Users have to sign a privacy policy that describes what personal information is collected, used and disclosed to other parties and for what purpose. *	A	A	A	A	A
R75	If the terms of participation change, the privacy policy should be updated immediately and this should be communicated to the users (via email, via push notification in app…). *	A	A	A	A	A
R76	Users have to sign the Terms and Conditions, that describe the rules they must follow in order to use hackAIR. *	A	A	A	A	A
R77	If the terms of participation change, the informed consent process should be repeated and users have to give their consent again (via email, via push notification in app…). *	A	A	A	A	A

5 Annexes

5.1 Annex 1: Topic list workshop phase I

The workshop consists of 4 parts. The first parts of the workshops focus on users' practices and expectations with regards to measuring and retrieving air quality information in general, whereas the last two parts focus on the hackAIR platform in specific.
Try to strictly follow the pre-defined timings of every topic and co-creation exercise.

Not every participant will arrive at the exact same moment. Upon entering and when waiting for the others, ask the participants to already fill in the survey and sign the informed consent.

- **The intake survey**: Say that the goal of this survey is to get some background information and set up a limited profile of the participants of this workshop.

- **The informed consent**: First orally explain to them what an informed consent is and what is in the document, and then give the participants the necessary time to carefully read the document.

1. Introduction - 5 min

- Start the workshop with presenting yourself and other researchers present.
- **Refer to the recording device(s) in the room**. Mention that this will only be used for the processing of the workshop, and the recording will never be used for another purpose. Only after this explanation, **switch the recording devices on**.
- Shortly **explain the goal of the workshop** (why are you here?) and **what a co-creation workshop is** and what is expected of the participants (e.g. there are no 'wrong' answers). State some ground rules (e.g. please don't interrupt others while speaking). (SLIDE)
- Give a short **overview of the agenda** and the topics to be discussed. (SLIDE)
- **Presentation of the workshop participants**: Do a round-table in which all the attendees can present themselves. Ask them to state their name, age, occupation

2. Current practices and experiences with regards to measuring and retrieving air quality information - 20 min

Start with some **open questions** about current practices and experiences with regards to measuring air quality and/or retrieving air quality information.

Retrieving air quality information:
- Do you sometimes search for AQ information?
  - **How** do you get informed about AQ? Do you use any websites, platforms, applications for this?
  - **When** do you search for AQ information? Do you do this often?
  - **Wha**t type of information do you look for?
- What are your experiences with retrieving AQ information?

- What do they like/dislike?
- Do you find all the information you need? (What is missing?)

Measuring air quality:
- Have you ever measured AQ yourself? How?
- What are your experiences here?
- Did you do something with the measurements? Did you make these measurements available to others (e.g. upload online)?

3. Motivations and expectations for using air quality platforms/applications - 30 min (total)

Before exploring different ideas and expectations with regards to the hackAIR platform/application, it is important to first explore the intrinsic (e.g. general environmental concern) and extrinsic (e.g. gamification goals and motivations users have for (not) using air quality platforms/applications.

Start with **open questions** to explore the (intrinsic) motivations for (not) using AQ platforms/applications. - 10 min
- Which AQ apps and platforms do you know and use? Why are you (not) interested in using these platforms/applications?
- What do you want to achieve by using these platforms/applications?

EXERCISE 1
Next, an **inspiration exercise** will be performed. Shortly present 3 existing air quality platforms/applications to the workshop participants (Plume air report, CityAir, Breezometer). - 5 min
- Of each platform/application, screenshots are taken. Show these first in the PowerPoint presentation, while shortly presenting the apps.
- Then also put hand-outs of these screenshots on the table so the participants can have a look at them again if necessary.
- A link to a short YouTube video presenting Breezometer is included in the slides. If Internet is available, show this movie clip.

Ask the participants to evaluate the platforms based on the following questions (SLIDE): - 10 min
- What are your first impressions with regard to the platform/application?
- What do you like about this platform/application?
- What don't you like about the platform/application?
- What is lacking in this platform/application?

Ask the participants to first individually write down their answers on sticky notes in different colours (one colour for each question). In the meantime, show the slide with on it the questions and colour code for each question to avoid confusion.
Hang three large paper sheets (e.g. flipchart paper) on the wall (one for every platform/application). Divide every sheet into four areas, one for every question. Ask the participants to put their sticky notes on the right sheet and right area on the sheet. In the meantime, the moderator and note-taker should group the sticky notes (e.g. put similar sticky notes together).
When all participants are finished, shortly discuss the main findings in group. - 5 min

4. hackAIR user scenarios - 35 min (total)

EXERCISE 2

Ask everyone to team up in pairs of two. Pass around hand-outs these scenarios/scene descriptions in the group so that the workshop participants can have a closer look at them. Give each group one scenario (3 pages: 1 in introduction page + 2 scene description (e.g. scenario template Karl). If there are more than 3 groups, give the scenario of Karl again to the 4th group.

Ask each team to evaluate the scene descriptions in the template by giving an answer on the following questions: - 15 min

–   What would you **keep** in this scenario?
–   What would you **change**?
–   What would you **delete**?

After filling in the papers, ask each team to quickly present what was in their scenario and what they would keep/change/delete.

The use of scenarios will help the workshop participants in getting an idea of the possibilities of the hackAIR platform. In the discussion that follows this exercise, ask following questions: - 20 min

–   *Would you be interested in using such a platform?*
    •   *When? Where? On which devices?*
–   *What are the most interesting features of the platform? Are there other things you want to be able to do with the platform?*
–   *What do you think about the game-elements in the platform? What game-elements or other rewards would you like the most?*
–   *Would you like to contribute with measurements yourself? How?*
    •   *Would you contribute with taking pictures? Via the app and/or via Instagram?*
    •   *Would you contribute using open hardware solutions?*

5. hackAIR low-fidelity prototyping

EXERCISE 3 - 25 min (total)

Ask everyone to pair up in the same team as in the previous exercise to create the wireframes. Pass around paper hand-outs with the empty standard frames of a smartphone screen, a tablet screen or a computer/browser screen. Ask each team to focus on one of the two scenarios they had to evaluate, and ask them to translate this into multiple wireframes that represent the interface and flow for this task. Let the teams choose themselves whether they want to create a smartphone, a tablet or a web app. - 15 min

To finish, give each team two minutes to present their creation. - 10 min

6. Closing – 5 min

At the end of the workshop, do a round-table again. This gives all attendees the opportunity to give a last comments or additional remarks on the discussed topics.

5.2 Annex 2: Scenarios workshop phase I

Future scenario 1: The BerlinAir platform

Location: Berlin
Actors:

- **Karl** (63), member of NGO 'CleanEarth', has high interest in air pollution, father of Anna
- **Anna** (32), full-time working pregnant woman with asthma, daughter of Karl, wife of Stephan
- **Stephan** (35), full-time working designer with more than moderate IT skills, runs half-marathons in his free time, husband of Anna
- **CleanEarth**, an NGO that just launched a campaign to raise awareness on the topic of air pollution

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Karl (63), is a retired teacher. Karl used to live in a highly polluted industrial area with his daughter Anna when she was a child. At the age of 10, Anna was diagnosed with Asthma. Karl feels responsible for his daughter's respiratory problems and since then he engages with the topic of air pollution. When they moved to Berlin, Karl became a **member of the NGO 'CleanEarth'.** *He is especially engaged in the working group on air quality and helps to raise awareness on air pollution and its possible effect on people's health. Karl has little technical knowledge and no smartphone, but he does frequently use his Android tablet.*

*Karl's daughter**, Anna,** is a 32-year-old woman with* **asthma** *and also living in Berlin. She lives only a few streets away from her father. Anna is* **five months pregnant** *of her first child. Since her pregnancy, Anna would like to get current local air quality information on a daily basis. However, Anna has a busy job as an architect and has little spare time left to fully engage in this. Anna has moderate technical skills, a cheap Android smartphone and goes to work by bike or subway.*

Anna is married to **Stephan**, *a 35-year-old graphic designer in a local communication agency. In his free time, Stephan trains to participate in an occasional* **half marathon.** *Stephan has quite some* **technical knowledge** *given his profession and education. He owns the latest iPhone and goes to work by bike.*

CleanEarth, *an environmental NGO, just launched a* **new campaign** *in Berlin together with a dedicated team of volunteers to try* **to raise awareness on the topic of air pollution among the citizens and policy makers in Berlin.** *They want to make citizens more informed about the air quality in their city to try to foster more 'environmental friendly' behaviour. They also want to start a discussion with the local government to start taking new measures to reduce air pollution.*

Part of this campaign is the **creation of a platform** *named BerlinAir where historical and quasi-real-time information on the particulate matter in Berlin (PM$_{2.5}$ and PM$_{10}$) is presented to citizens, organisations and policy makers. Upon the platform, a web app and mobile application (iOS & Android) has been build. Existing* **open data** *sets from* **Berlin.de** *are included in the platform, as well as air quality data from the European Data Portal datasets. In addition, they asked the* **government agency 'Umweltbundesamt',** *an environmental protection agency, to give access to the official measurements on small particles that are gathered by the calibrated fixed sensors that are installed in the city. This took a lot of time as the department initially was very critical about the initiative. They had bad experiences with alike campaigns as they were very accusing on the department's policy and measurements and the government didn't want to live this again. But finally, they decided to agree. In addition to these data,* **citizens** *can also contribute with air quality measurements. They can do this in two ways: by taking and* **uploading pictures of the sky** *(1) and/or by* **uploading sensor data** *(2).*

- (1) The geo- and time-tagged pictures can be uploaded to the platform via the mobile application or the can be uploaded to Flickr or Twitter with the official hashtag #BerlinSky.
- (2) Citizens could buy a BLE enabled sensor for 20 Euro to support the sensing of air quality
- (3) Citizens could buy an Arduino based air quality sensor that they could program themselves for 40 Euro

*To foster citizens' community feeling and engagement, **gamification** elements (points for contributions, badges and other rewards), were integrated in the applications and friendly competition was created between the **different districts in Berlin**.*

*At the start of the campaign, **info sessions are organized in each district in Berlin** to raise awareness on the campaign and to explain to citizens how they can contribute. The info sessions are given by the **local CleanEarth volunteers** and help in building a community. Extra **workshops** are organized for citizens interested in using the measuring toolkit, **to explain how to set up and use the sensors**.*

*Karl is part of the **dedicated team of CleanEarth volunteers that supports the campaign**. He engaged in giving the info session in the district where he lives and is trying to build a community of interested citizens in his city. He asked local businesses in his district to hang up a **poster** or leave **flyers** and contacted **local media** with the **press material created by CleanEarth**. Karl is trying to get as many people as possible on board to upload pictures because he would like his district to be one of the top-contributing districts. Karl takes and uploads sky pictures to the platform multiple times a day with his tablet. He can't upload his pictures when he is on the road with his tablet because he has no mobile internet subscription. Luckily all the pictures he takes are geo-tagged, so it is still useful to upload the pictures at a later moment at home on the same day. Karl is in the top 3 of top-contributors in his district. Top 3 contributors get a 'top contributor' badge on his profile page. If he gets a notification that another user is close to taking over his spot in the top 3, he increases his number of daily uploaded pictures for a short time to keep his position. When he was installing the BerlinAir application, he was for a moment a bit concerned about his **privacy** as the application told him it would give access to the location information of his device when taking pictures. He read the hackAIR privacy statement again. Although he didn't really understand it, he decided to accept application settings anyway because Karl wanted to explore the application immediately. There was an email address stated in the privacy statement to which questions regarding the privacy policy can be send, and Karl decided to maybe mail at a later moment to ask what it all means. Although he didn't really understand the answer, he decided to accept it. Karl has created a **profile** on the platform, and he has indicated he has asthma. This way, **when he gets an air quality notification on his tablet for people with asthma, he can inform his daughter on this**. He knows that Anna doesn't always have the time to regularly check the air pollution levels and she doesn't get personalized notifications on her phone since she hasn't installed the application. After some weeks though Karl decides it hadn't been such a good idea to be the intermediate person in this communication as he only could access the information on his tablet at home. So, he decides to add Anna her mobile phone number to his profile and indicates that the notifications need to be sent to the phone number of Anna as well.*

*Anna doesn't like to install new applications on her phone because it has very little memory space left. Therefore, she **uploads her sky pictures to Flickr or Twitter** with the **official hashtag** and **a location tag**. Anna likes to go to work by bike, but if certain air pollution levels are too high she takes the subway as a precaution for her asthma. Only in the morning, before she leaves for work, Anna uses the web application to check the current air quality measurements. As the messages of her father arrived rather late, she was happy that she now receives an SMS of BerlinAir directly on her mobile phone when the particulate matter was getting really high in Berlin. In the web application, Anna has indicated that she is **pregnant** and that she has **asthma**.*

*Karl bought two **sensor toolkits** for his son in law Stephan, the **BLE** one and the **Arduino** one. Stephan assembled the toolkits, using the guidelines provided. He attached the Arduino one to his balcony (shielded from the rain) to keep track of the air quality evolutions in his street. The BLE one he attached*

*on his office building. When creating the account, he was asked if he wanted to become part of the community of the region where the design office is situated. He sent an email to his colleagues with information on how they can install the free app to receive the air quality notifications via Bluetooth on their mobile phone just by walking by. All sensor data are automatically uploaded to the BerlinAir platform via the **Wi-Fi** connection at his home or in the office. Stephan is very happy to see that the sensors are wireless and he doesn't have to attach any power supply to it. He can just stick it somewhere and start measuring. Stephan also informs Anna if the PM limits are too high. Stephan always uses the BerlinAir platform to check the air quality measurements to decide on which locations it is most suitable to go running and to search for alternative routes with less air pollution. If the air quality is too bad everywhere in the city, he trains indoor on a treadmill. In the profile he created on the BerlinAir platform, Stephan indicated he **exercises outdoors every day**.*

Thanks to help of many volunteers that succeeded in engaging multiple local communities, the campaign is a success. Part of the success is due to the fact that citizens can already contribute with a low effort (e.g., uploading a picture) and reward features make it fun to do so. Many pictures are uploaded daily.

Karl is happy that he helped in raising awareness on air pollution and hopes that more people will change their behaviour. Anna, being pregnant, and Stephan, training for a half-marathon, feel more comfortable knowing that they can get a regular update on the air quality.

Besides a general overview page with an elaborate list of ways citizens can reduce harmful emissions air, the platform also gives users personalized recommendations on how they can reduce their contribution to air pollution. When creating their profile, users were asked to indicate whether they own a car, have a wood stove at home … On days when the air pollution levels are too high, citizens with a car for example get the recommendation to avoid using the car that day or people with a wood stove to limit the burning of wood in the home context. These recommendations are then sent to the mobile app with a push notification (can be switched off). This feature was very popular and well-received among the users of the platform. The community portal dedicated to ways to reduce air pollution is one of the most popular community portals. The participants started even discussing new ways to decrease air pollution. This has also caught the attention of local policy makers and might benefit CleanEarth in their discussions with the local government on new measures to reduce air pollution.

Assumptions covered in the scenario:

- The platform will target both 'basic participants' and 'expert participants' (see Deliverable D2.1 for explanation of these types of participants).
- Stakeholders can use the data to act as services providers, service orchestrators and/or decision maker.
- Images only are useful if they contain a good deal of sky.
- Images only are useful if they are geo-tagged and time-stamped.
- Quasi-real-time data is data that is maximum 24h old.
- An Android and iOS app will be made.
- There will be no major difference between the web app and mobile app.
- Gamification elements will be included in the web and mobile app to trigger user contributions.
- Users will be able to create a profile with personal information and in which they can indicate certain personal characteristics such as 'I'm pregnant' or 'I have asthma'.
- End users only have access to the general air quality data and not to their own uploaded data.

Future scenario 2: The Air+ platform

Location: Ghent
Actors:

- **Nature+**, a local health NGO that received funding to build an air quality platform (Air+)
- **Bart** (26), communication and IT employee of Nature+
- **Chris** (30), wants to create an app with air quality information on the parks and playgrounds in Ghent
- **The city of Ghent**, support open innovation and is willing to place extra sensors

'Nature+' is small local NGO in Ghent that strives for the well-being and a healthy habitat for the citizens of Ghent. Besides a network of volunteers, they have 8 employees. One of the employees of Nature+ is **Bart (26),** who takes care of the website and all communication activities. Bart started working at Nature+ three years ago, after finishing his degree in web development.

Recently, Nature+ obtained a little bit of **funding** from the city of Ghent for a new project. The goal of the project is the **creation of an open platform or tool that brings together (open) data on air quality of Ghent and makes this easily accessible to every citizen**. Bart leads the project, and has some support of an intern who studies software development. Because the budget and manpower is quite small, they wanted to make the **platform (Air+)** very simple. They looked at what already exists and is used by other NGO's or projects. They found that there are plenty of them, and most often build from scratch, or only consisted of a dedicated application build upon one specific citizen-generated data source. The goal of the project of Nature+ is raising the awareness of citizens on the topic of air quality. The main feature they foresee is the display of air quality information ($PM_{2.5}$, PM_{10}) from different sources in various ways (temporal view, spatial view, comparative view) of the different districts in Ghent. They also want that the available data and visualisation types are accessible via API, because they want other people to build applications upon their platform.

While searching for existing platforms that they could use, Bart encountered the hackAIR platform. He analysed the technical information on hackAIR that is available online and learned that the platform was an open platform that could be used for free by NGO's to create own environmental awareness platforms. He could download the source code from GitHub and install the platform on his own premises, or he could ask for a dev account to get access to the platform and create an own version of it that he could adapt upon his wishes. Bart chose for the second option as he thought this would be the best way to see how it worked. He asked the hackAIR admin for a dev account and received in within some hours, together with a Q&A on how to get started to create your own platform. He logged in to the hackAIR platform and started creating it. He soon encountered some problems on how to add data streams from the city of Ghent. The Q&A helped Bart in solving most problems, and for the remaining one he posted his problem on the community portal for developers and asked for help. He soon got some answers and solutions from other developers.

He wanted to add air quality measurements from various sources in the platform:

- The European open data was no problem as they were already accessible via the hackAIR platform.
- He knew the 'Vlaamse Milieumaatschappij' (VMM), a local government agency, has five fixed air quality measurement stations in Ghent. Every hour, air quality values ($PM_{2.5}$, PM_{10}, NO_2) are calculated and published online. Nature+ has negotiated with VMM if they could integrate the VMM measurements into their platform. They got the permission, but now had to make it work.

– Sensor data from citizens. Bart used the Nature+ communication channels to find people who have an air quality sensor or operate an amateur measuring station willing to integrate these data into the platform. This was quite an intensive task as there is such a diverse set of measurements stations available. Therefore, he decided to first make a list of types of stations that are possible to integrate with the platform, write a manual for the operators of these stations on how to integrate their data in the platform and then to relaunch the question more concrete.

After he developed the Air+ platform, Bart also creates a **mobile application** *for the (quasi-)real-time display of air quality information and via which people could upload picture to the platform as data source on particulate matter. In the first stage, only an Android application was developed. Bart has an Android phone himself and prefers Android over iOS, and he also didn't want to depend on the sometimes-ambiguous Apple app review process. To stimulate interaction with citizens, Nature+ created* **a hackAIR community portal for Air+** *and integrated this in their platform. The community platform has the Air+ colours and logo. Citizens can use this community portal for discussion and to freely download monitored air quality data as open data sources.*

To stimulate the creation of new services with the open-air quality data, Nature+ organizes a **hackathon**. *One of their partners for this event is the city of* **Ghent**. *The city of Ghent wants to support open innovation and they would like to more actively involve citizens into the improvement of governance and public services. They created an online open data portal with many public datasets that citizens can use for the creation of new services. One of the open datasets contains information on all the playgrounds in Ghent and another one on all the parks. One of the participants of this hackathon is Chris.*

Chris *(30) lives in Ghent with his wife Inge (30) and their daughter Lisa (3). Chris and Inge live in the city centre but since housing is quite expensive there, they live in a rather small house without garden. When the weather is nice, they often relax in one of the many nice parks in their neighbourhood. There also are quite some playgrounds in Ghent to which Lisa likes going to. Because he is raising his kid in a city, Chris started paying attention to the air quality in Ghent. Chris learned about Air+ and the hackathon via the Nature+ weekly newsletter. Before Chris goes to a park or playground with his family, he sometimes uses the Nature+ platform to look for the area in Ghent with the cleanest air and then decides to go to a park or playground in that area.*

Chris and his team decide to **make an application to give parents and other interested citizens of Ghent easy access to air quality data of the different parks and playgrounds in Ghent.** *He integrated in this application the Nature+ air quality data and the park and playground open data sets of the city of Ghent.*

However, there is no precise data available for every park or playground. Ideally, a sensor should be present at each park or playground. However, Chris doesn't have the resources for this, nor the permission to place sensors at public places. After the hackathon, Chris contacts Bart about this and asks if Nature+ could help in contacting local authorities for the placement of sensors in parks and playgrounds. Bart likes this idea because this could enrich the Air+ air quality measurements database, and it could lead to more users of their platform. Together with Chris, he presents the idea to the local authorities. They like this idea as well, since it fits within the open innovation policy track of the city and it is a concrete result of the hackathon, an event they helped organizing. They decide to place air quality sensors in a couple of the bigger parks and playgrounds in the city.

Since still not every park or playground is covered now, Chris decides to add an extra feature to the application. People present in a park or playground can indicate on a scale from 1 (highly polluted) to 5 (no pollution) how they perceive the air quality there. It is also possible for users to add descriptive qualitative information. In the platform, these perceptions of air quality will be clearly distinguished from the actual measurements to avoid confusion.

The hackathon was a success. Not only did it lead to an increase of the users of Air+, it also led to the creation of some interesting services. One of them even resulted in the placement of extra air quality sensors. The local authorities are also happy with the results of the project and the active engagement of citizens with regards to the platform. The city decides to use Air+ to report on the air quality during the very popular yearly festival 'Gentse Feesten' in the city centre of Ghent.

Assumptions about hackAIR covered in the scenarios:

- The platform will target both 'basic participants' and 'dedicated participants'.
- Stakeholders can use the data to act as services providers, service orchestrators and/or decision maker.
- Quasi-real-time data is data that is maximum 24h old.
- There will be no major difference between the web app and mobile app.
- The community portal is based on the web app, but will exist as a stand-alone app apart from the web app or integrated in other platforms.
- Some light customization of the community portal will be possible (e.g., logo, colour scheme).
- Basic features of the community portal have to be installed on the client's server and will be offered for free.
- End users only have access to the general air quality data and not to their own uploaded data.
- End users will also be able to add their perceptions of the air quality on specific locations.

5.3 Annex 3: Topic list workshop phase II

In the second workshop phase the list of user requirements and the corresponding features will be validated. The mock-ups developed by DRAXIS (WP5) will act as a discussion starter and as a basis to gain in-depth feedback on the main functionalities of the hackAIR applications. Building further upon the identified main functionalities, an elaborate set of specific hackAIR features will be validated. Specific attention will be paid to the gamification features. Also, in this workshop privacy expectations with regards to the hackAIR platform will be explored (part of the PIA) and first explorations of the open hardware sensor measurements.

Not every participant will arrive at the exact same moment. Upon entering and when waiting for the others, ask the participants to already fill in the informed consent. First orally explain to them what an informed consent is and what is in the document, and then give the participants the necessary time to carefully read the document.

1. Introduction - 5 min

– Start the workshop with presenting yourself and other researchers present.
– Refer to the recording device(s) in the room. Mention that this will only be used for the processing of the workshop, and the recording will never be used for another purpose. Only after this explanation, switch the recording devices on.
– Shortly explain the goal of the workshop (why are you here?) and what a co-creation workshop is and what is expected of the participants (e.g. there are no 'wrong' answers). State some ground rules (e.g. please don't interrupt others while speaking). (SLIDE)
– Give a short overview of the agenda and the topics to be discussed. (SLIDE)
– Presentation of the workshop participants: Do a round-table in which all the attendees can present themselves. Ask them to state their name, age, occupation.
– Shortly present the hackAIR project/platform.

2. Validation of the main functionalities of the hackAIR application - 30 min

After shortly explaining what the goal is and/or should be of the hackAIR platform, the different developed **mock-ups** (**DRAXIS**) will be shortly presented to the workshop participants. These mock-ups are used to gain feedback on the main functionalities of the hackAIR applications. To gather the feedback, a role-playing exercise will be performed. Groups of users will be assigned a certain role (e.g. environmental activist) with which they have to emphasize, and they have to evaluate the mock-ups from that point of view (Is all the info they need in there? Does the app help in reaching their goals?). Persona cards will be created with a short explanation of the persona and why he/she wants to use hackAIR.

EXERCISE 1
Present the mock-ups with PowerPoint (one slide for each mock-up). Pass around hand-outs of these screenshots around so the participants can have a look at them again. Staple the hand-outs of the mock-ups of the web app together (3 pages) and staple the hand-outs of the mock-ups of the mobile app together (2 pages).

Divide the participants into 3 groups. Give each group one persona card.
- Anna (27): a woman with asthma
- Stephan (35): a sports and health enthusiast

- Karl (63): an environmental activist

Next, give each group the mock-ups to give feedback on. Ask them to discuss the mock-ups from the point of view from their persona. Ask the group to write their feedback on a paper form with 4 questions:

- *What are your first impressions?*
- *What would you keep?*
- *What would you change?*
- *What would you delete?*

Encourage the participants to make notes and/or adjustments on the printed mock-up hand-outs as well.

After everybody has filled in the forms, ask each group to shortly present their evaluation of the mock-up. Discuss the feedback in group.

Extra questions:

- *Generally, do you like the look & feel?*
- *'Submit your feeling': Other people's perceptions of the AQ, will be depicted on the map with dots. Apart from the visualization on the map, can you think of other ways on how you want to see other people's perceptions of the AQ? (specific question from DRAXIS)*

3. Validation of the wireframes: gamification - 15 min

Gamification elements will be included in the web and mobile app to trigger user contributions and user engagement. Workshop phase I pointed out that the integration of game elements was perceived very well. Explore in this part of the workshop the gamification dynamics and what exact gamification features users are interested in with the wireframes provided by Luducrafts.

EXERCISE 2

Very shortly show the wireframes to the participants and explain what they represent (e.g. This is an example of a mission. If it pops up on your screen, you can choose to accept or decline it. If you accept it and do the mission, you receive points for it).

Divide the participants again in the same three persona groups as in the first exercise and ask them to emphasize again with their character. Give a set of wireframes to each group. Ask them to discuss these wireframes in the groups (5 minutes). Give each group 2 markers (different colours, e.g. red & green) and ask them to indicate on the wireframes in green what they like (e.g. drawing circles, crosses) and in red what they don't like. Encourage the participants to make notes and/or adjustments on the wireframes if they want to.

Have a group discussion afterwards:

- *What do you think of the missions?*
  - o *Would you like to receive regular notifications with missions you can do?*
- *Would you like to challenge other people and friends who also use hackAIR? Would you like doing challenges yourself?*
  - o *Can you think of fun challenges you would like to do or send to others?*
- *What do you think of the fact that you can gather points by using hackAIR?*
  - o *Would you like receive points for your contributions to the platform (upload photo, sensor data), for the actions you do to reduce air pollution, and for the challenges you win? For what else should you receive points?*
  - o *Do you like it that you can see the total score of the other users?*

- *Do you like the badges?*
  - *For what should users receive a badge created? E.g. when you have uploaded 10 pictures, when you are the top contributor of the week, …*
- *Can you think of other game elements that would be nice to have in the applications?*

4. Validation of the specific features of the hackAIR application - 20 min

Besides discussing and evaluating the main functionalities, these mock-ups also facilitate the translation of these main functionalities into a more elaborate set of specific hackAIR features. In this part of the workshop, we will discuss the different features. To help the discussion, each possible feature will be written down on a card. These cards have to be made before the start of the workshop.

EXERCISE 3

Divide the participants again in the same three persona groups as in the first exercise. Give a set of cards to each group. Give the participants the time to read all the cards with the features. Provide some extra cards and ask them to write down possible features they think are missing on an empty card. These cards can be added to the collection of cards on the table.

First let the groups discuss the features from the point of view from their persona. Give each group 2 markers (different colours, e.g. red & green) and ask them to do the following:
- Ask them to select the 3 features they like the most (are a must to have) and mark these cards with a *green* dot
- Ask them to select the 3 features they like the least (are not a must to have) and mark these cards with a *red* dot

Next, let each group to evaluate the features again, but now from their personal point of view (and not from their persona's point of view). Ask the participants to group together all features into 3 groups:
- Features that are a must have
- Features that would be nice-to-have
- Features that aren't a must have

Print labels for each group so the participants can easily group the cards under the right label ('must have', 'nice to have', 'no must have').

5. Privacy - 15 min

As part of the hackAIR Privacy Impact Assessment (PIA), in the workshop first insights will be gathered with regards to users' current privacy concerns and practices.

EXERCISE 4
When creating a hackAIR profile, participant will be given the option to fill in different types of personal information. Based on the personal information the user has provided, he/she will receive personal recommendations and notification. Ask the participants which types of personal information they have no problem with sharing, which information they will maybe share and which types of information they will not share. Ask each participant to fill in the created form.

Have a short discussion afterwards and ask the participants for additional remarks.
- *How do you decide what information to provide and what information not?*

- *Would you lie about certain information?*
- *How do you want to be informed about the proposed uses of hackAIR of your personal data? Is the description of this in the privacy policy sufficient?*

EXERCISE 5
Different factors can determine whether or not a website or service is deemed trustworthy to handle your personal data. Ask the participant what factors they think are important. Ask each participant to fill in the created form.

6. Open hardware - 10 min

Users will also be able to contribute to hackAIR with sensor measurements. Design guidelines will be provided for easy-to-assemble sensor toolkit (BLE or Arduino), so citizens can measure air quality themselves with a sensor.

Ask the following questions:

- *Are you interested in measuring AQ yourself with a sensor?*
- *Would you want to buy a sensor? Why (not)?*
- *A clear user guide with instruction on how to assemble the sensors will be created. Is this sufficient for you? Would you be interested in participating in a workshop in your city to assemble the sensors together with others?*
- *Sensors can also be installed at a public place, making it possible for people passing by to collect and view the sensor measurement by switching on the Bluetooth on their mobile phone. Would you be interested in this?*

7. Closing – 5 min
At the end of the workshop, do a round-table again. This gives all attendees the opportunity to give a last comments or additional remarks on the discussed topics.

Ask them if they are interested in participating in future phases of the hackAIR project.
In the second workshop phase the list of user requirements and the corresponding features will be validated. The mock-ups developed by DRAXIS (WP5) will act as a discussion starter and as a basis to gain in-depth feedback on the main functionalities of the hackAIR applications. Building further upon the identified main functionalities, an elaborate set of specific hackAIR features will be validated. Specific attention will be paid to the gamification features. Also, in this workshop privacy expectations with regards to the hackAIR platform will be explored (part of the PIA) and first explorations of the open hardware sensor measurements.

5.4 Annex 4: The hackAIR mock-ups

WEBSITE (1) – homepage

WEBSITE (2) – Compare air quality cities

WEBSITE (3) – My profile
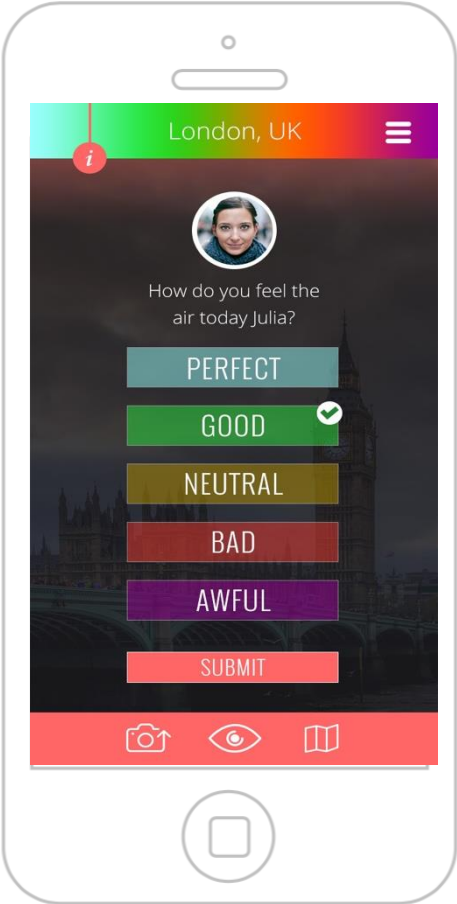
MOBILE APP (1) – Air quality info
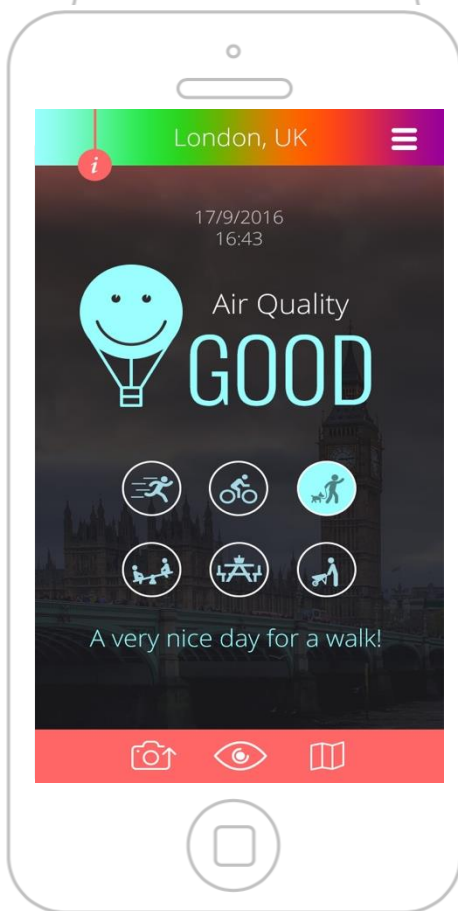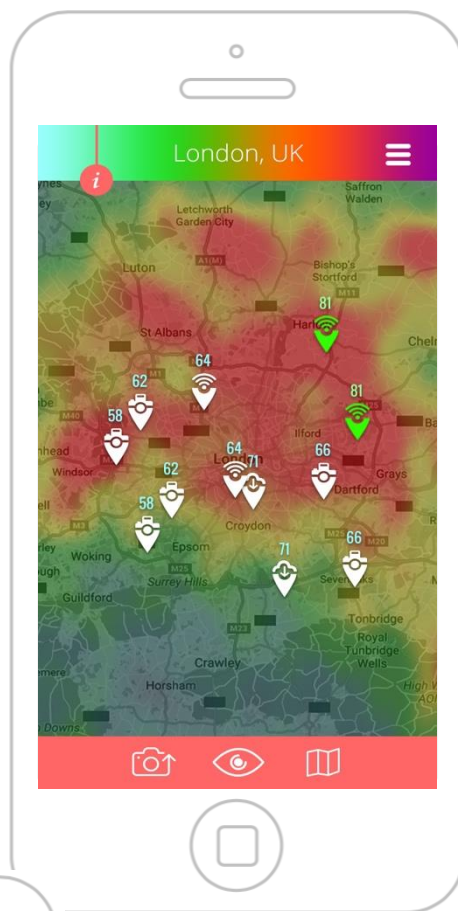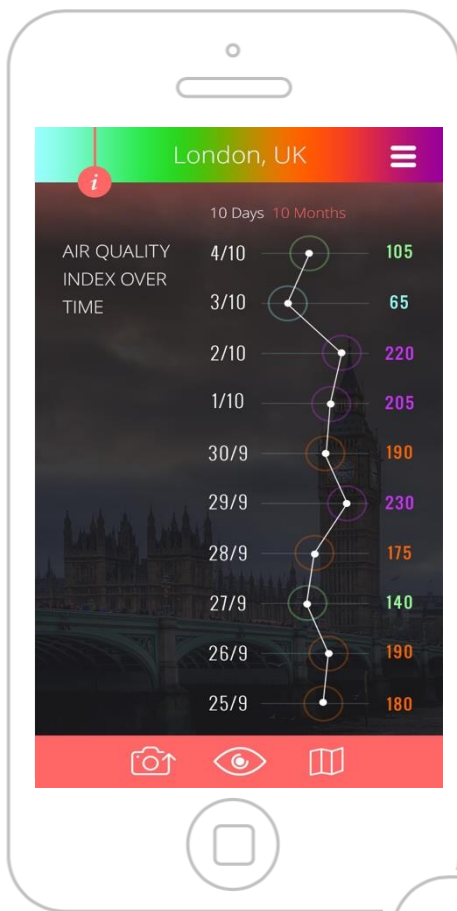
MOBILE APP (2)

Contribute with data
(pictures, sensor data)
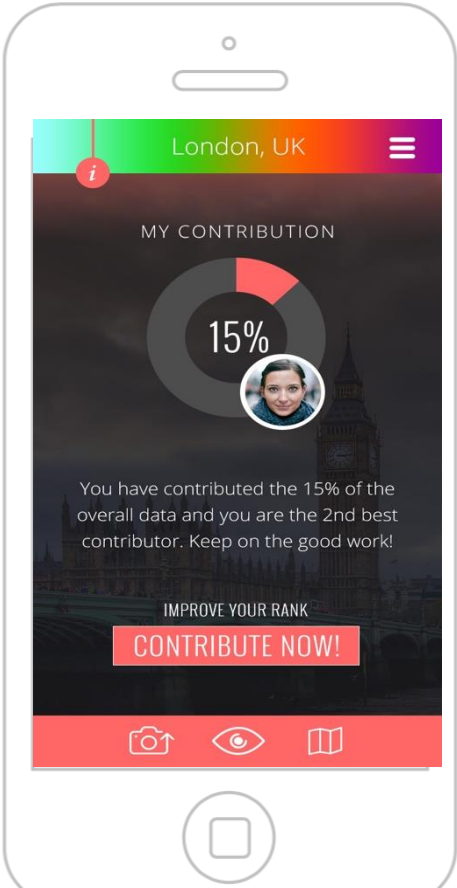
Submit how you feel about the air quality

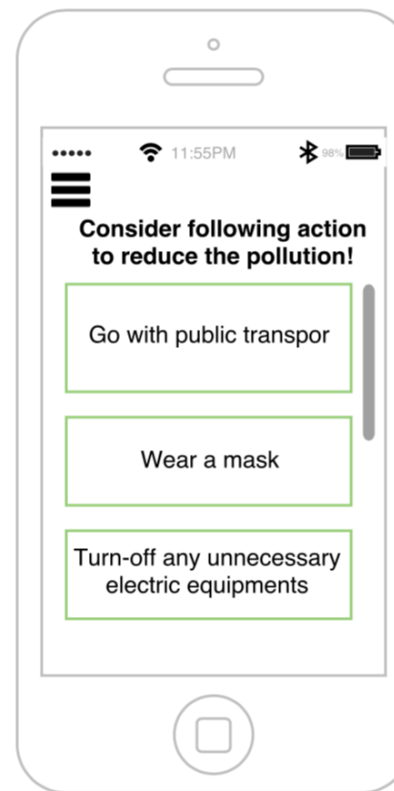# 5.5 Annex 5: The gamification wireframes

QUICK MISSION 1

Daily reminders (push notification)

Hey, don't forget to protect the air! Here is a quick hack for you!

Quick missions

Your today's mission:

Snap a picture of the sky!

(tap for more info)

decline   accept

Details of mission (avaliable when taping on the screen)

Your today's mission:

Explanation
By posting a photo of the sky, we are able to determine the quality of the air in your area.

decline   accept

Rewards and recognition (after finishing the mission)

Great, you just helped to create some fresh air! +100 points

Wow! You become an **AIR HUNTER!**
Tap for more information

See my dashboard

QUICK MISSION 2

Notifications about poor air

Watch out! You are in the area of poor AQ, see how you can fight it!

→

Offers suggestions for actions that helps to reduce AQ and protect oneself

Consider following action to reduce the pollution!

Go with public transpor

Wear a mask

Turn-off any unnecessary electric equipments

→

Rewards, if choose one of the suggestions.

Great, you just helped to create some fresh air! +100 points

Thanks you, you brought here some fresh air!

See my dashboard
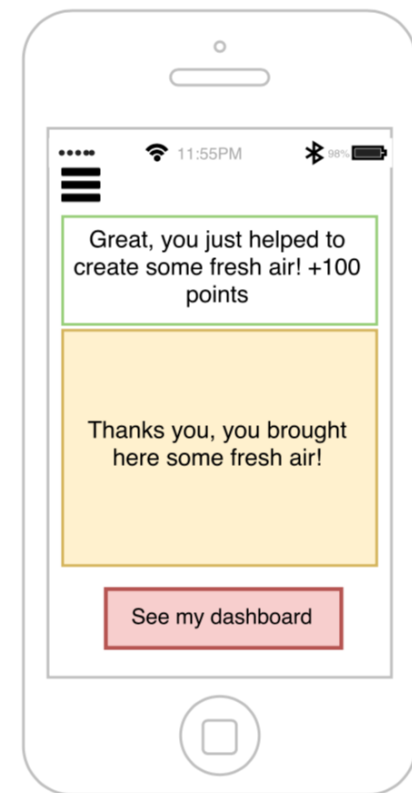
CHALLENGE ANOTHER PERSON

Hamburger menu to navigate through app / mobile view.

List of avaliable missions / hacks

Mission's detail
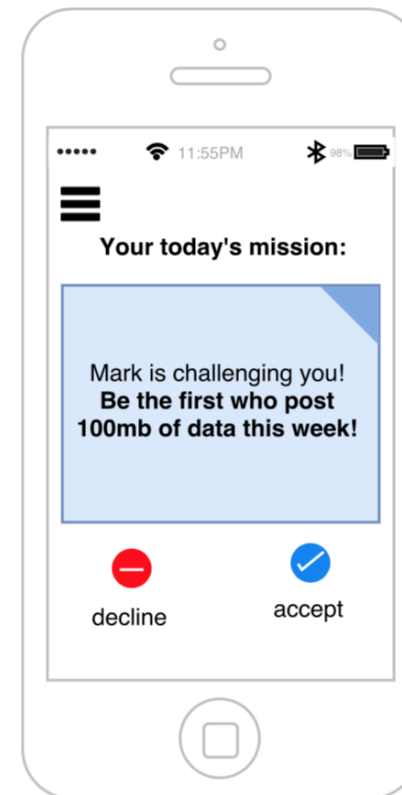
Menu ☰
Information about AQ
My dashboard
Missions to hack air
My achievements
Community
Settings

→

☰ **Hacks avaliable** 🏆

Your progress in Hack Air

| My hacks | Actual | Complete | All hacks |

Snap a picture
Set up an tracking device
1 on 1 challenge
Post 200mb of data
Submit my feeling
Invite a friend

→

☰

Missions details:

Challenge on of your friends!
**Be the first who post
100mb of data this week!**

⊖ decline   ✔ accept

hackAIR
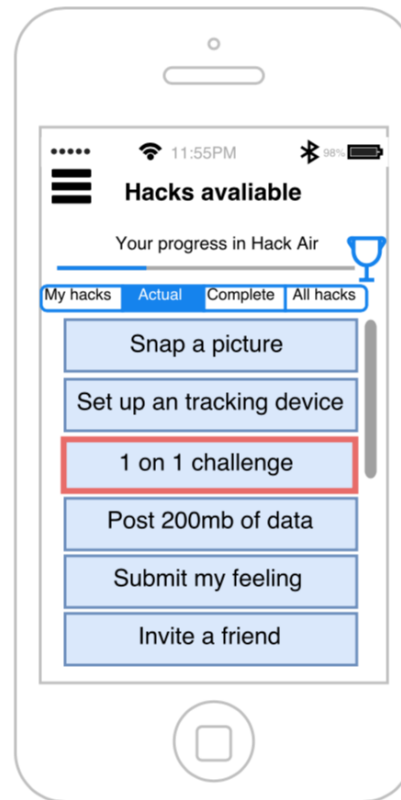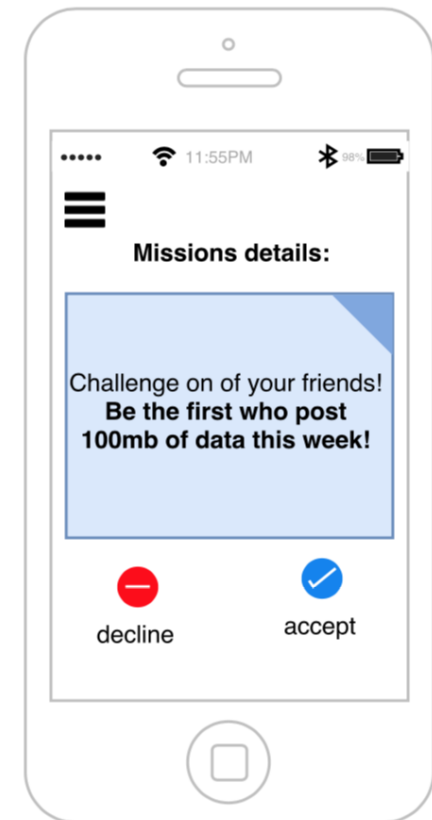
RECEIVE A CHALLENGES

Social dynamic, special challenges.
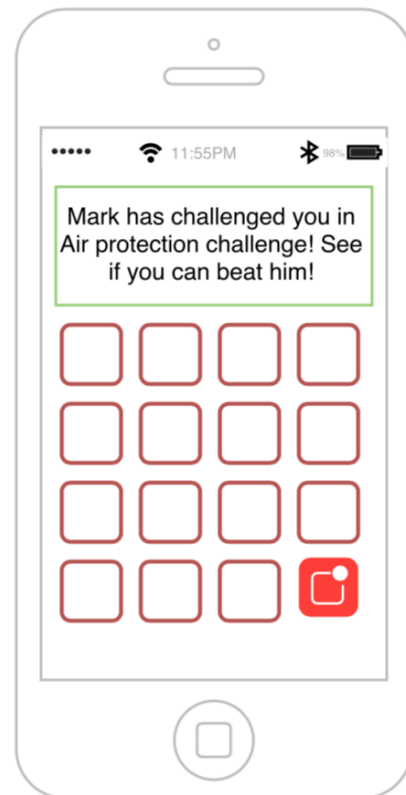
Friendly competition between users.

CHECK YOUR ACCHIEVEMETNS

Example of "my achievements " page

Menu

Information about AQ

My dashboard

Missions to hack air

My achievements

Community

Settings

Screen shows 2 tabs: Leaderboards and Achievements (badges)

11:55PM

You achievements
Your progress in Hack Air

| Achievments | Leaders |

Your rank: #5   Score: 220

Improve my rank!

Complete missions and save environment along the way!

Leaderboard:

1. Isabelle......................345p
2. Joseph.......................320p
3. Mika...........................290p
4. Daphne......................245p
5. Marcus.......................220p
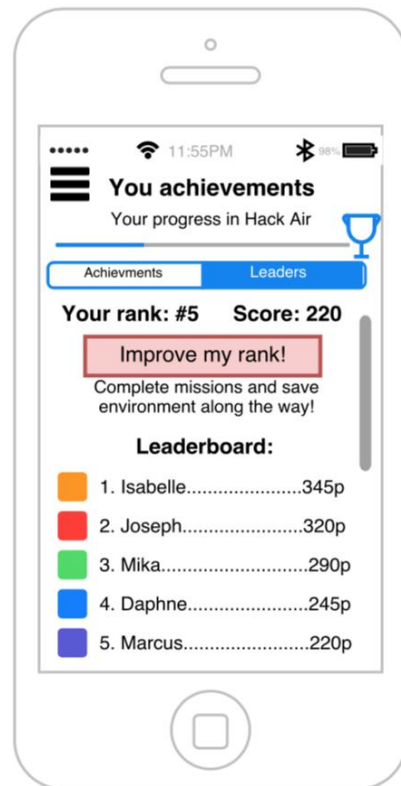
Both screens shows overall progres bar of user

11:55PM

You achievements
Your progress in Hack Air

| Achievments | Leaders |

Name   Badge

Badge   Badge

Complete missions and save environment along the way!

Earn more rewards!
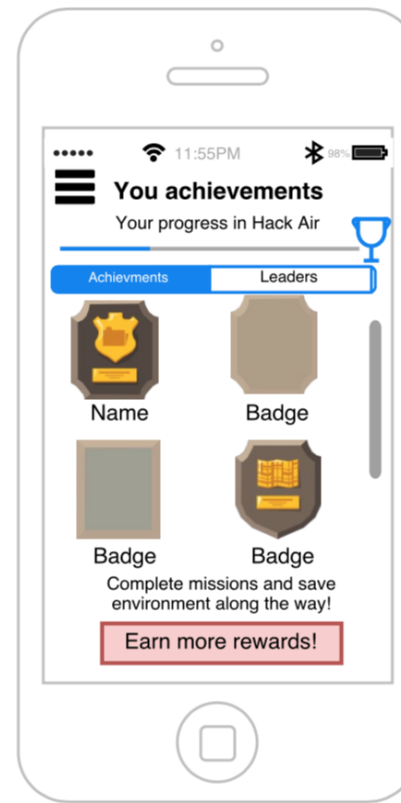
When taping on badge, detail pops out.

11:55PM

You achievements
Your progress in Hack Air

| Achievments | Leaders |

Air hunter
Make and upload at least 10 photos of the sky.

Badge   Badge

Complete missions and save environment along the way!

Earn more rewards!
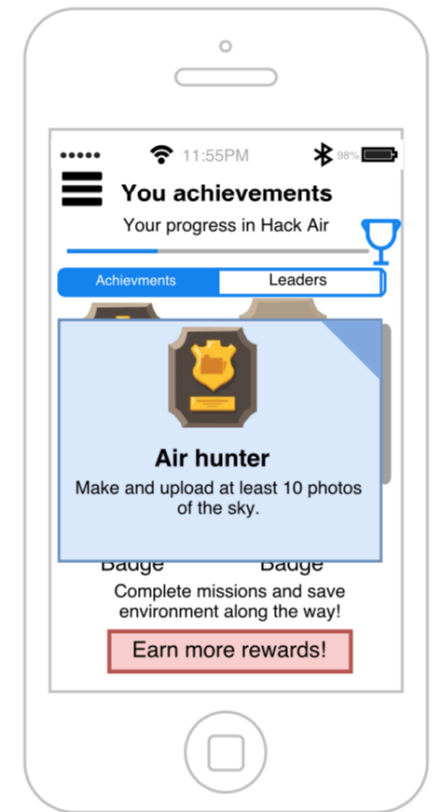
hackAIR

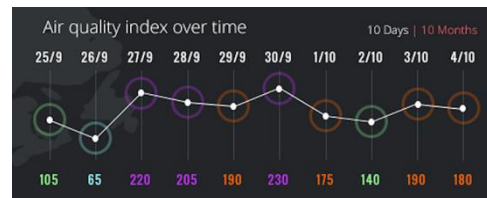## 5.6 Annex 6: The possible hackAIR features

Access real-time data about air quality in your city

Access historical data about air quality in your city

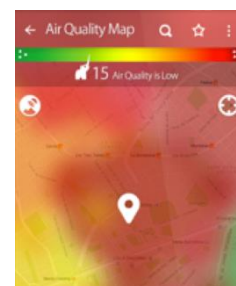Access forecast data about air quality in your city

Timeline with the air quality evolutions

Compare [...] th other

Spatial view of the air quality (heat map)

Read tips on what you can do to reduce air pollution

Read tips on how to limit your exposure to air pollution

Message board: Ask questions to other users and discuss relevant topics

See who in my neighbourhood is also using hackAIR

Login with my social media account (e.g. Facebook)

Cancel   **Sign in**

Sign in with Facebook

Sign in with Google+

MAIL
Your email address

PASSWORD
Your password

See who of my friends from social media are using hackAIR so I can connect with them in hackAIR

Create a profile

Connect ('Friend') with other hackAIR users

Learn more about air quality, the sources of air pollution the effect of air pollution on health

Check which outdoor activities I should or shouldn't be doing today

Receive <u>app notifications</u> on my mobile device with air quality updates

Receive <u>email notifications</u> with air quality updates

Receive <u>SMS notifications</u> with air quality updates

Receive notifications with recommendations on what to do when the AQ is bad (e.g., "Don't use your car today")

Receive notifications with recommendations on how to limit your exposure to pollutants (e.g. alternative biking route)

Contribute to air quality measurements by taking and uploading pictures of the sky through the mobile app
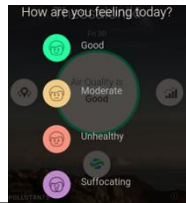
Contribute to air quality measurements by taking and uploading pictures of the sky on social media using the hackAIR hashtag

Contribute to air quality measurements by uploading the data of my air quality sensor
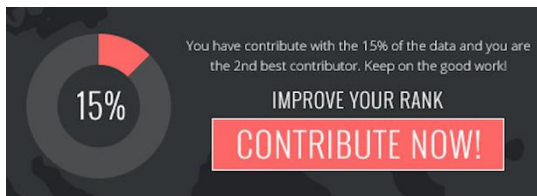
Submit my perception of the atmosphere by entering a rating on the air quality for a specific location and check other users' perceptions
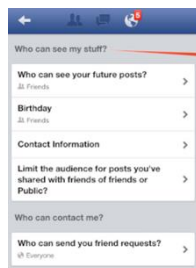

Check how my submitted perception of the air quality relates to the actual AQ

See what the level of my contribution is

Receive feedback on the quality of the data I send

Adjust the privacy setting of your profile and personal information

Check the contributions of other users

Earn points for contributions

Unlock badges

See your ranking compared to others

GAME LEADERBOARD		
RANK	**NAME**	**POINTS**
1	Alexander C.	1,500
2	Cameron O.	1,400
3	Molly I.	1,300
4	Julia G.	1,200
5	Keith S.	700
YOUR POSITION		
RANK	**NAME**	**POINTS**
23	Joe S.	400
24	Keith S.	350
25	You.	250
26	Matt T.	200