



## **Horizon 2020**

### **Societal Challenge: Improving the air quality and reducing the carbon footprint of European cities**



ICARUS

#### **Project: 690105 – ICARUS**

Full project title:

**Integrated Climate forcing and Air Pollution Reduction in Urban Systems**

#### **D7.1 Technical report on user requirements and functional specifications of ICARUS DSS**

##### **WP7: Motivating citizens towards the vision**

Lead beneficiary: AUTH

Date: June 2017

Nature: Report

Dissemination level: Public

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	WP7: Motivating citizens towards the vision	Security:	Public
	Author(s): AUTH, UPCOM, KARTEKO, ARTEMIS	Version: Final	2/62

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### Document Information

<b>Grant Agreement Number</b>	690105	<b>Acronym</b>	ICARUS
<b>Full title</b>	Integrated Climate forcing and Air pollution Reduction in Urban Systems		
<b>Project URL</b>			
<b>Project Officer</b>	Mirjam Witschke - <a href="mailto:Mirjam.WITSCHKE@ec.europa.eu">Mirjam.WITSCHKE@ec.europa.eu</a>		

<b>Delivery date</b>	<b>Contractual</b>	January 2017	<b>Actual</b>	June 2017
<b>Status</b>	Draft <input type="checkbox"/>		Final <input checked="" type="checkbox"/>	
<b>Nature</b>	Demonstrator <input type="checkbox"/>	Report <input checked="" type="checkbox"/>	Prototype <input type="checkbox"/>	Other <input type="checkbox"/>
<b>Dissemination level</b>	Confidential <input type="checkbox"/>		Public <input checked="" type="checkbox"/>	

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### Document History

Name (Institution)	Date	Version
AUTH	January 2017	1.0
UPCOM	February 2017	1.1
ARTEMIS	April 2017	1.2
KARTECO	May 2017	1.3
AUTH	June 2017	Final

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## 1 Introduction

For a number of historic reasons, response strategies to air pollution and climate change are often addressed by different policy institutions. However, there is growing recognition that a comprehensive and combined analysis of air pollution and climate change could reveal important synergies of emission control measures which could be of high policy relevance. Insight into the multiple benefits of control measures could make emission controls economically more viable, both in industrialized and developing countries. While scientific understanding on many individual aspects of air pollution and climate change has considerably increased in the last years, little attention has been paid to a holistic analysis of the interactions between both problems.

In this context, the Decision Support System (DSS) we will develop in the frame of ICARUS is mainly intended to assist policy makers in the decisional process in the selection, application and evaluation of the available datasets and tools for urban impact assessment in support of air quality and climate change governance at different spatial and temporal scales and taking into account the specific regulatory context.

The aim of this document is to provide the basic concepts for the development of the ICARUS DSS which will be the computational environment that brings together the different tools available from the ICARUS consortium addressing all the aspects of the full chain for urban impact assessment of policies options.

The platform design will follow a tiered architectural paradigm, coupling web-enable functionalities and services with a central service manager and a geo-referenced database that would allow consistency of data usage and servicing among different sectorial applications. The software will be implemented taking into account the currently available specifications of the INSPIRE directive and in particular the provisions of the Draft Implementing Rules and of the Data Specifications for an enhanced interoperability.

A further goal of the ICARUS project, besides improving the determination of air quality parameters, is also to diffuse and to share with a network logic the information obtainable by the system with the operators and decision makers of the air quality management sector, using the most advanced telematic infrastructures. In the framework of the project, an active user consultation has taken place during the first months of the project. These activities which will continue during the DSS implementation phase have allowed addressing the system functionalities towards different needs of the users, starting from the actual requirements on the ICARUS platform.

The scope of this document is not to provide the complete guidebook towards the development of the ICARUS DSS; rather, it seeks to provide a good basis to foster the discussion and exchange of ideas among the project team and key stakeholders towards the final blueprint of the ICARUS DSS.

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## 2 Methodology

A set of questions was prepared in order to be included in the questionnaire survey using the Delphi methodology and distributed via email to the key stakeholders identified. These stakeholders included local public authorities responsible for urban resilience, air pollution and environmental management, local health operators, industry, local and regional/national academia, international organizations (e.g. WHO, EEA) NGOs active in urban resilience issues and in environmental health and well-being, as well citizen associations.

The questionnaire focused on the main functionalities, data requirements and data storage needs. Specifically, questions on the scientific content and expected results as well as software interaction styles, design criteria, user input, DSS outputs, status info, errors and rollback, documentation features, data persistence features, internet browser preference (for compatibility issues) were formulated based on a grade rating system from 1 to 5 (1 for least important, 5 for most). In cases where further explanation was needed, in accordance with the Delphi procedure, repeated Delphi panels comprising different stakeholders were consulted under the responsibility of the project coordinator. The final results of all panels were synthesized and they are reported in summary below. According to the feedback received the user requirements should comprise the following:

- Use ICARUS DSS as a tool for developing environmental management and policy decisions to ensure protection of public health.
- Aid to the organization of Action Plans aiming at reducing the exposure of local population to ambient air pollution focusing on the most toxic components thereof, such as particulate matter, ozone, NO<sub>x</sub> and black carbon.
- Design of a user-friendly and readily accessible Web-based air quality and carbon footprint information service.
- Possibility to communicate the resulting data in the form of maps, tables, and time series diagrams.
- Include some basic analysis and geospatial tools for data processing
- Low operational cost to the users and ease to use (on-line help and guidance at all times).
- Supply of appropriate staff training to local users.

Poor environmental decision information can imply later reconstruction or introducing other measures in order to achieve necessary air quality standards. Such costs by far exceed the costs for an appropriate environmental planning tool in the early stages of an urban planning process. Getting as much "value for money" as possible is a political topic and a real necessity in many cities in Europe. Consequently, the ICARUS DSS should be primarily designed to support the urban planning activities and environment and health studies.

In addition, the need for cost effectiveness is also applicable for the air quality management system itself. Therefore, it is important to find the best cost-effective monitoring techniques and modelling tools.

Other key requirements expressed by stakeholders included:

- Existing spatial databases at the cities level must be readily importable to the ICARUS

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DSS and data management system to render it readily operational

- Assessment of contribution of different emission sources (including natural sources) to the total concentrations of different pollutants (i.e. source apportionment).
- The possibility of getting results from the simulation of different policy options and technological measures (how they will impact on the AQ and CF levels)
- A guided procedure for future scenario design to allow users to formulate their own scenarios for various parameters should be incorporating in the system.
- Identification of hot spot areas where policy-makers need to focus to improve AQ
- Download of data
- Flexibility: the ICARUS DSS should be a modular, multi-user and multitask system. To this end it is of vital importance that:
  - It can support the simultaneous use of a high number of users
  - the covering geographical area can be modified/extended for a better transferability of the system
  - complementary methods and modeling tools can be seamlessly added at a later stage if needed

In addition, other stakeholders identified specific functionalities which they think would be extremely useful if through this project some or the total of the following could be produced on an operational basis:

- Daily monitoring of air quality.
- Frequency of annual exceedances of limit values.
- Optimisation of the monitoring network.
- Fundamental research on atmospheric pollution phenomena in particular PM generation and diffusion.

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### 3 Definition of the user requirements of the ICARUS DSS

There are multiple stakeholders in ICARUS with various needs and interests. ICARUS intends to satisfy these needs and offer a new, integrated approach for urban impact assessment in support of air quality and climate change governance. The majority of local authorities and industries are interested in receiving the data produced by the DSS. They consider that these data will contribute in improving the reliability of the services they provide in terms of air pollution control.

They also expect to use the DSS in order to design more efficient policies for improving air quality in their jurisdictions. Several industries are interested in getting information on the environmental impact of the solutions they design and propose. City partners need to have a clear image of urban air quality in real time and in better resolution than stable measurement stations can offer. City partners and citizens are interested in having a tool that will notify them in case of pollution limits exceedance and also see periodic statistics on how often this happens.

Key stakeholders need to access this information in a human-friendly and easily understandable way. Seeing data on interactive maps using layers with different colors and textures will help them easily perceive the presented information. More specialized users need to access also numeric and geospatial data in high accuracy; for the latter, numeric tables must be also used, as well as the possibility to import and export data in several file formats has been requested.

The majority of local authorities and industries are interested in receiving the data produce by the DSS and they consider that these data will contribute to:

- Better design environmental policies and measures, by being able to simulate them and see their estimated impact
- Study the aforementioned impact in several different sectors, starting from emissions and pollutant concentrations, down to population exposure, public health and economic costs
- Keep track of the implementation of those measures and evaluate their results

A brief presentation of the stakeholders is presented hereafter, before presenting the functional and non-functional user requirements in higher detail.

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### 3.1 Stakeholders

In the context of ICARUS DSS proper functional design and upcoming development, it is of great importance to classify in detail the stakeholder groups taking into consideration the necessity of multiple ICARUS stakeholders and their various needs and interests as previously mentioned. In the ICARUS 'Deliverable 8.2 - Dissemination Strategy Report' and 'Deliverable 8.3 - Stakeholder Engagement Strategy Report', Stakeholder affiliations and groups are presented in detail providing full description of their relevance to ICARUS project and additionally, the appropriate dissemination actions to engage stakeholders and raise awareness on air pollution, climate change issues and citizen's wellbeing are analyzed. In brief, the Stakeholder affiliations and groups are mentioned below.

Identifier	Name
S1	City partners: 1st stakeholder group – oriented to City partners, Municipalities, Public authorities, Civil protection agencies, Community medical staff, Communal information centres 2nd stakeholder group – oriented to Civil society, Main polluters, Local population, Public figures, Investors, Business figures, Fora for public health
S2	Engineering sector: city planners, engineers, architects & designers, environmental professionals
S3	Medical sector: Hospitals, Medical staff, Health care providers
S4	Industry & SMEs: Private/commercial sector, Chemical sector, Manufacturing sector, ICT sector, SMEs
S5	Decision & policy-making/regulatory bodies: Relative Ministries, Municipalities, Politicians, European Commission, European Parliament, European Council
S6	Academic/Scientific community: University Community (Students & Staff), Researchers, Leading scientific programmes
S7	International organizations: World Health Organization, United Nations
S8	Non-Governmental Organizations: Environmental organizations, Public health organizations, Consumer rights organizations
S9	Media & press: Local & nation-wide news agencies, TV & radio stations, City bloggers and journalists, Health & Environment journalists
S10	Citizens: Citizens are already included in S1, but they are mentioned here separately due to the special focus they get by the DSS, their contribution through the user-centric tools and the citizen engagement orientation of the ICARUS project
S11	ICARUS DSS team: The SMEs of the Consortium that will develop and later on provide the DSS to all

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other stakeholders

All stakeholders, regardless their power, they are a critical element for the progress of the project that will a) help guide the overall research direction and Decision Support System (DSS) design to ensure relevance; b) provide local knowledge and insight for specific case studies; and c) aid dissemination and impact.

Overall, ICARUS DSS aims at supporting stakeholders with technical recommendations depending on their needs on air quality information, carbon footprint levels, climate change and health impact assessment. For a simple user/citizen, ICARUS DSS will be an informative platform on air pollutant parameters and climate change indicators. For extra and more individual information for citizen's actions related to air pollutant exposure and health risk/benefit, wearable devices in collaboration with user-centric tools will be applied and developed respectively, drawing information from the ICARUS DSS and combining it with the citizen's unique exposure profile.

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## 3.2 User requirements

### 3.2.1 Functional user requirements

The functional requirements collected during this project phase and confirmed by the relevant stakeholders using the Delphi methodology, are outlined below:

Identifier	Name	Priority <sup>1</sup>
UR_F1	The Icarus DSS must estimate the expected environmental and health impact of a policy option or a technological measure in a region	Must
UR_F2	The DSS should store the results of the simulations performed for policy options or technological measures	Should
UR_F3	The DSS must allow viewing the results of simulation for predefined policies and/or technological measures in a region	Must
UR_F4	The DSS user must be able to view the results of the impact in various formats, including maps, tables and/or time series	Must
UR_F5	The DSS user must have the ability to process the results using geospatial tools	Must
UR_F6	The DSS should provide tools to record policy or measures engagement	Should
UR_F7	The DSS could compare simulation results of the past with actual status, based on realized policies or measures	Could
UR_F8	The DSS must allow inputting new emission measurements and integrate it with the existing data available to the DSS	Must
UR_F9	The DSS must allow inputting new pollutant concentrations and integrate it with the existing data available to the DSS	Must
UR_F10	The DSS user must be able to specify "hot-spot" areas and focus the analysis on them	Must
UR_F11	The DSS must allow collecting data from the user-centric tools	Must
UR_F12	The DSS must provide information back to the user-centric tools	Must
UR_F13	The DSS must allow the definition of geographical entities and decentralized management	Must
UR_F14	The DSS must keep track and/or regulate usage of resources for	Must

<sup>1</sup> The MoSCoW ([https://en.wikipedia.org/wiki/MoSCoW\\_method](https://en.wikipedia.org/wiki/MoSCoW_method)) method of specifying the priority of a user requirement has been adopted: Must Have, Should Have, Could Have and Won't Have.

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	billing purposes	
UR_F15	The DSS must allow viewing and exporting emission measurements for a region over time	Must
UR_F16	The DSS must allow viewing and exporting pollutant concentrations for a region over time	Must
UR_F17	The DSS must secure access to the system, with various levels of security depending on the user	Must
UR_F18	The DSS must provide a guidebook on best practices to the public, based on the experience gained through the system	Must
UR_F19	The DSS should support import of spatial databases at the city level	Should
UR_F20	The DSS should support “source apportionment”, the assessment of contribution of different emission sources to the total concentration of different pollutants	Should
UR_F21	The DSS could support daily monitoring of the pollutants in an area/region	Could
UR_F22	The DSS could provide statistics on annual exceedance of limit values per geographical entity	Could
UR_F23	The DSS could help optimize the monitoring network	Could

### 3.2.2 Non-Functional Requirements

Identifier	Name	Priority <sup>2</sup>
UR_NF1	The use of DSS should have low cost compared to existing solutions	Should
UR_NF2	The use of DSS must be as user friendly as possible	Must
UR_NF3	The DSS must provide training to local users	Must
UR_NF4	The DSS should be modular, multi-user and multi-tasking	Should
UR_NF5	The DSS should support a high-number of simultaneous users	Should
UR_NF6	Fundamental research on PM generation and diffusion	Could
UR_NF7	The DSS should support adding complementary methods and modelling tools seamlessly	Should

<sup>2</sup> The MOSCoW method of specifying the priority of a user requirement has been adopted.

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<b>UR_NF8</b>	The DSS should support the definition of a new modelling scenario based on the respective modelling parameters	Should
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### 3.3 Detailed functional user requirements

In the next paragraphs, each functional requirement is detailed; based on those details, the list of User Stories has been elaborated and agreed with the stakeholders, as the first round of Functional Specifications of the Icarus DSS.

The non-functional requirements are detailed in the “Deliverable 7.2 - Report on the design of technical framework and system architecture of the ICARUS DSS”, as they heavily affect the design of the system.

Code number	UR_F1
Name	The Icarus DSS must estimate the expected environmental and health impact of a policy option or a technological measure in a region
Stakeholder(s)	Decision & policy-making/regulatory bodies, City partners, Academic/Scientific community, Engineering sector
High level description	<p>Air quality and climate of urban regions has a significant impact in the health and the well-being of the population. The situation that has been created in an area is usually the result of the actions and omissions of several years and any policy changes to improve it need considerable time to show if they are effective or not and much more to produce the desired results. Careful planning and expertise is required to develop effective policies. ICARUS DSS aims to assist environmental services and decision makers to decide on policies concerning air quality and climate in urban areas by enabling them to estimate what the impact of each “candidate” policy will be before applying it.</p> <p>The stakeholders should be able to experiment with various scenarios and get quantitative estimates of the impact of each one of them. To do so, they should be able to create policy scenarios concerning the presence (number) of polluters in each area and the emission levels each of them will be producing. They should also be able to define different values for these factors over the course of time.</p> <p>After providing the system with these parameters, they will be able to see information on the impact of each policy under examination on the following aspects:</p> <ul style="list-style-type: none"> <li>• Air pollutants and greenhouse gases emissions</li> <li>• Air pollutants and greenhouse gases concentrations</li> <li>• Population exposure levels</li> <li>• Population health</li> </ul>
Issues and benefits	The benefits of the use of ICARUS DSS by authorities and environmental services are:

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Notes	<ul style="list-style-type: none"> <li>• The ability to experiment with many different policies</li> <li>• The quantitative estimates of the impact of each policy in many different levels (emissions, concentrations, population exposure, health impact, monetary evaluation)</li> <li>• The ability to foresee the results of a policy before implementing it, based on real data of the specific geographical region</li> </ul>
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Code number	UR_F2
Name	The DSS should store the results of the simulations performed for policy options or technological measures
Stakeholder(s)	Decision & policy-making/regulatory bodies, City partners, Academic/Scientific community, Engineering sector
High level description	<p>When applying a policy on air quality and GHGs emissions, policy makers need a way of evaluating the efficiency of the measures taken. To this end, the DSS should offer them the possibility to the estimated results of each policy that has been simulated using the DSS, so that they can compare them with the real impact of the applied policy and re-evaluate, if needed, their approach.</p> <p>In the process of deciding upon a policy, users are expected to experiment with several scenarios, which need time to create and resources to execute. The DSS should consequently persist these scenarios, so that the users do not have to start from scratch each time they need to compare their alternatives.</p>
Issues and benefits	<p>A possible issue of this requirement is the size of data that some of the models produce as output.</p> <p>Implementation of this requirement will offer the following benefits:</p> <ul style="list-style-type: none"> <li>• Evaluation of the efficiency of a selected policy over time</li> <li>• Saving time from the user, by not forcing them re-create and re-execute existing scenarios from scratch</li> <li>• Economy of computational resources</li> </ul>
Notes	

Code number	UR_F3
Name	The DSS must allow viewing the results of simulation for predefined

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	policies and/or technological measures in a region
<b>Stakeholder(s)</b>	Decision & policy-making/regulatory bodies, City partners, Academic/Scientific community, Engineering sector, Medical sector, Industry & SMEs
<b>High level description</b>	During the project, based on the data available to the consortium, the most basic policies and measures will be evaluated in terms of expected impact in emissions, population exposure and public health. These basic scenarios along with their estimated impact will be readily available to the users of the DSS, so that they can easily retrieve the foreseen efficiency of the most common policies/measures.
<b>Issues and benefits</b>	The users will be able to get impact estimates without having to create a policy from scratch and avoiding the time and resources needed for the execution of a non-standard simulation.
<b>Notes</b>	

<b>Code number</b>	UR_F4
<b>Name</b>	The DSS user must be able to view the results of the impact in various formats, including maps, tables and/or time series
<b>Stakeholder(s)</b>	All
<b>High level description</b>	<p>The results of running the policy evaluation models are mainly of geo-spatial nature and vary over time. This means that they cannot be easily perceived by humans, unless they are appropriately visualized on maps, using WebGIS technology, such as highlighting areas with layers corresponding to different value ranges. Since the results concern time periods rather than specific moments, the user must be able to change the period of which the data is projected each time.</p> <p>In the same time, the users must still be able to see numeric values in detail, since this is important for the quantitative evaluation of the policies.</p>
<b>Issues and benefits</b>	<p>The DSS will offer the users the possibility of:</p> <ul style="list-style-type: none"> <li>• An easy visual representation of the results</li> <li>• A more detailed appreciation of the values</li> </ul>
<b>Notes</b>	

<b>Code number</b>	UR_F5
<b>Name</b>	The DSS user must have the ability to process the results using geospatial tools
<b>Stakeholder(s)</b>	Decision & policy-making/regulatory bodies, City partners,

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	Academic/Scientific community, Engineering sector
High level description	<p>The results of the scenario execution are mainly of geo-spatial nature and concern the whole area for which the simulation has been run. The users should be able to process the results using <b>geo-spatial</b> tools, in order to extract useful information that they can base on to evaluate the impact of their (candidate) policies in specific regions.</p> <p>These geo-spatial tools are of various levels of complexity, ranging from basic analysis to complex spatial procedures and refer to the analysis of vector and/or raster data. The list of geo-spatial tools available to the DSS user can be roughly distinguished in 3 categories:</p> <ul style="list-style-type: none"> <li>- <b>Extraction tools:</b> Includes tools for extracting parts of data, according to specific sets of rules or relationships, such as has specific attribute, intersects, is at a distance of, is contained by etc.</li> <li>- <b>Statistical analysis and measurement tools:</b> Includes summary statistics for raster files, where count, sum, mean, stddev, min and max can be calculated and tools for measuring attributes of vector files, such as perimeter, area etc.</li> <li>- <b>Conversion tools:</b> Includes tools for converting data to different types or formats, such as converting a vector geometry to raster and vice versa, converting a polygon to lines, lines to points or calculating an interpolated value for a pixel using the values of the pixel's neighborhood.</li> </ul>
Issues and benefits	Applying geospatial tools on the simulation results enables the users to convert data to valuable information.
Notes	

Code number	UR_F6
Name	The DSS should provide tools to record policy or measures engagement
Stakeholder(s)	Decision & policy-making/regulatory bodies, City partners
High level description	The policy makers typically use DSSystems to perform what-if analysis on possible policy and/or technological measures application. This requirement allows policy makers to record their decisions and re-evaluate them based on their actual measured impact, after the application of the measures.
Issues and benefits	By enabling policy makers store the decided measures and policies and track their results, they will be able to evaluate and if needed adapt them accordingly in the future.
Notes	

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<b>Code number</b>	<b>UR_F7</b>
<b>Name</b>	The DSS could compare simulation results of the past with actual status, based on realized policies or measures
<b>Stakeholder(s)</b>	Decision & policy-making/regulatory bodies, City partners
<b>High level description</b>	The impact of policies and measures changes over the course of time, and sometimes policies call for regulations that can vary over time as well. Users should be able to compare the real impact of a policy with the estimated one in several periods, so that they can extract conclusions on their effectiveness.
<b>Issues and benefits</b>	The user's benefit by comparing the actual impact against the estimated one is that they will be able to have a quantitative index of the efficiency of the simulations they run.
<b>Notes</b>	

<b>Code number</b>	<b>UR_F8</b>
<b>Name</b>	The DSS must allow inputting new emission measurements and integrate it with the existing data available to the DSS
<b>Stakeholder(s)</b>	Decision & policy-making/regulatory bodies, City partners, Academic/Scientific community, Engineering sector Citizens
<b>High level description</b>	It is crucial for the sustainability of a system like ICARUS DSS to be able to keep it updated, by providing it with new emissions data, so that it can recalculate the estimated impact on air quality and public health. It does not only serve the purposes of comparison between actual and estimated policy impacts as described in UR_F7, but it also ensures that the DSS will remain a valuable source of up-to-date information both for the decision-makers and the general public.  In order to make this data feeding process feasible and practical, we need to clearly define models that will define the exact format under which data should be fed to the DSS.
<b>Issues and benefits</b>	By enabling the integration of new emission measurements, the system can: <ul style="list-style-type: none"> <li>• Base its output on the latest data available</li> <li>• Provide up-to-date information to the public</li> </ul>
<b>Notes</b>	

<b>Code number</b>	<b>UF_F9</b>
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<b>Name</b>	The DSS must allow inputting new pollutant concentrations and integrate it with the existing data available to the DSS
<b>Stakeholder(s)</b>	Decision & policy-making/regulatory bodies, City partners, Academic/Scientific community, Engineering sector Citizens
<b>High level description</b>	This requirement is the equivalent of UR_F8, but for the pollutant concentration measurements. On top of this, it allows the integration of data collected by the wearables and the user-centric mobile application.
<b>Issues and benefits</b>	By enabling the integration of new pollutant concentrations, the system can: <ul style="list-style-type: none"> <li>• Base its output on the latest data available</li> <li>• Provide up-to-date information to the public</li> <li>• Integrate information provided by the user-centric tools</li> </ul>
<b>Notes</b>	

<b>Code number</b>	<b>UR_F10</b>
<b>Name</b>	The DSS user must be able to specify “hot-spot” areas and focus the analysis on them
<b>Stakeholder(s)</b>	Decision & policy-making/regulatory bodies, City partners, Academic/Scientific community, Engineering sector
<b>High level description</b>	There are some areas that require more focused analysis on air quality and population exposure, such as neighborhoods with high traffic congestion, or areas close to polluters. By allowing the users to run more detailed analyses on those areas, instead of their whole geographical entity, the time and resources needed are minimized.
<b>Issues and benefits</b>	This requirement offers the users the benefit to adapt the detail from area to area according to their interests.
<b>Notes</b>	

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<b>Code number</b>	<b>UR_F11</b>
<b>Name</b>	The DSS must allow collecting data from the user-centric tools
<b>Stakeholder(s)</b>	<p>Citizens</p> <p>Industry &amp; SMEs</p> <p>Decision &amp; policy-making/regulatory bodies, City partners, Academic/Scientific community, Engineering sector</p>
<b>High level description</b>	<p>As part of the ICARUS project, user-centric tools will be developed and made publicly available to citizens at several scales in order to collect data on population exposure to pollutants and user behavior in urban environments (such as ways of transportation, itineraries used etc.).</p> <p>ICARUS DSS needs to collect all this data in a regional basis so that they can be used for the exposure analysis of each region.</p> <p>Respecting user's privacy is key factor in the process of collecting the data; to ensure privacy, citizens should:</p> <ul style="list-style-type: none"> <li>• Be accurately informed on the nature of data they share</li> <li>• Be able to inspect their data by logging in to the system</li> <li>• Be sure that their data will remain confidential</li> </ul>
<b>Issues and benefits</b>	<p>Collecting data from the wearables and the smartphone application:</p> <ul style="list-style-type: none"> <li>• Raises privacy issues while it</li> <li>• Offers the DSS the benefit of gaining valuable information on the real exposure data of the population at a very high spatial (down to 10m) and temporal scale that could not be retrieved by the traditional means of collection (measurement stations).</li> </ul>
<b>Notes</b>	

<b>Code number</b>	<b>UR_F12</b>
<b>Name</b>	The DSS must provide information back to the user-centric tools
<b>Stakeholder(s)</b>	Citizens
<b>High level description</b>	<p>Apart from supporting decision-makers in making effective policies, ICARUS project aims to also sensitize and engage citizens in order to finally modify their behaviors by the adoption of practices that improve health directly or indirectly (through the reduction of the emission of pollutants). To this end, the user-centric mobile application will not only collect data from the user, but it will also receive from the DSS valuable information on:</p>

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	<ul style="list-style-type: none"> <li>• Real-time or near real-time data on air-quality at their location</li> <li>• The prospected impact of their behavior on air quality and urban climate</li> <li>• The prospected direct and indirect impact on their health</li> </ul> <p>Providing this kind of feedback back to the users plays a key role to citizen engagement, as it serves as a basic reward to their contribution.</p>
Issues and benefits	<p>The benefits of providing information back to the users are:</p> <ul style="list-style-type: none"> <li>• Sensitizing and engaging the citizens, by</li> <li>• Analyzing to them the impacts of their own behaviors and</li> </ul> <p>Rewarding them for their contribution</p>
Notes	

Code number	UR_F13
Name	The DSS must allow the definition of geographical entities and decentralized management
Stakeholder(s)	<p>Decision &amp; policy-making/regulatory bodies, City partners, Academic/Scientific community, Engineering sector, <b>International organizations, Non-Governmental Organizations</b></p> <p>Industry &amp; SMEs</p>
High level description	<p>Policies and their impact must be studied in various geographical scales and this is also reflected in the target users of the DSS, who are decision-makers and/or environmental services of local, regional and state authorities. Since the use of the DSS will be offered as a service to them, there is a need to enable the service provider to create geographical entities and assign them to the clients. Those geographical entities will be of different scales (city, region, country) and could also overlap each other (e.g. if a regional authority and a municipal authority within this region are both using ICARUS DSS).</p> <p>Each client should be able to manage the accounts of their users in a decentralized way; i.e. each client will be able to create, modify and delete user accounts for their own geographical entity. This is crucial to the scalability of the DSS, as otherwise all those demands would pass through the service provider.</p>
Issues and benefits	<p>By defining geographical entities and assigning them to each client, we can:</p> <ul style="list-style-type: none"> <li>• Provide each client with the data they need for their</li> </ul>

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	<p>geographical entity</p> <ul style="list-style-type: none"> <li>• Increase the usage autonomy of the client</li> <li>• Decrease the work load of the service provider</li> </ul>
Notes	

<b>Code number</b>	<b>UR_F14</b>
<b>Name</b>	The DSS must keep track and/or regulate usage of resources per geographical entity for billing purposes
<b>Stakeholder(s)</b>	Decision & policy-making/regulatory bodies, City partners, Academic/Scientific community, Engineering sector Industry & SMEs
<b>High level description</b>	The DSS will be provided as a paid service to administrations and environmental services. Multiple billing plans must be supported, such as pay-as-you-go, fixed price, by number of users, etc. In order to implement such billing policies, we need to monitor and register the resources used by each geographical entity. This information must be available to the Service provider, so that they can charge the users accordingly. Usage and billing information must also be available to the administrative accounts of each geographical entity, so that they can have a clear view of the costs of their usage and/or their remaining resources that are including in their plan.
<b>Issues and benefits</b>	Collecting usage information and making it available to both clients and the service provider offers the benefits of: <ul style="list-style-type: none"> <li>• Having a clear view of the system's usage</li> <li>• Helping clients control their costs of usage</li> </ul> Ensuring transparency in billing
Notes	

<b>Code number</b>	<b>UR_F15</b>
<b>Name</b>	The DSS must allow viewing and exporting emission measurements for a region over time
<b>Stakeholder(s)</b>	Decision & policy-making/regulatory bodies, City partners, Academic/Scientific community
<b>High level description</b>	Data from emission measurements are valuable to policy makers. Since they are geospatial data that also change over time, the DSS must present them to the users using human-friendly visualization techniques of Web-GIS technology. The user should be able to project

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	<p>the values on a map for the desired period.</p> <p>Users should also be able to extract emission data from the DSS, so that they can use them for their own purposes. By doing so, the DSS will become a system that not only collects and processes data, but can also export them for the use of other systems.</p>
<b>Issues and benefits</b>	<p>This requirement offers the following benefits to the users:</p> <ul style="list-style-type: none"> <li>• Easily gain an overall impression of the emissions over the course of time</li> <li>• Use data exported by the DSS for their own purposes.</li> </ul>
<b>Notes</b>	

<b>Code number</b>	<b>UR_F16</b>
<b>Name</b>	The DSS must allow viewing and exporting pollutant concentrations for a region over time
<b>Stakeholder(s)</b>	Decision & policy-making/regulatory bodies, City partners, Academic/Scientific community
<b>High level description</b>	The same description applies here, as described in UR_F16 for emission data.
<b>Issues and benefits</b>	
<b>Notes</b>	

<b>Code number</b>	<b>UR_F17</b>
<b>Name</b>	The DSS must secure access to the system, with various levels of security depending on the user
<b>Stakeholder(s)</b>	Decision & policy-making/regulatory bodies, City partners, Academic/Scientific community Industry & SMEs
<b>High level description</b>	<p>The DSS will be used by several user types and each of them will handle data of different importance and sensitivity.</p> <p>For all user accounts, a username (identical to the user's e-mail address) and a secure password will be asked each time the user wants to log in to the system.</p> <p>The user accounts related to the service provider will be able to manage users' information, billing information, and will have access to data which can be personal, confidential, or under a restrictive license. They will also have the privilege to manage client accounts, including deleting them, access billing information etc. It is crucial to protect these accounts from malicious access. The same requirements are valid</p>

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	<p>to a lesser extent for accounts related to the local, regional or state authorities.</p> <p>Citizens' accounts must also be protected from unwanted access, since some of them will provide the system with data on their daily activities and pollutants exposure by using the user-centric tools.</p> <p>To address this, we will also provide the service providers and local, regional and state authorities accounts with two-factor authorization techniques (2FA).</p>
Issues and benefits	<p>The following issues are raised by this requirement:</p> <ul style="list-style-type: none"> <li>• The possibility of loss of access to one of the means of the two-factor authentication mechanism (mobile phone)</li> <li>• Higher complexity of the log-in procedure, which some users might find disturbing</li> <li>• The choice of a password that is not secure enough</li> </ul> <p>The benefits for the DSS users will be:</p> <ul style="list-style-type: none"> <li>• More secure accounts</li> <li>• Ensuring data privacy and confidentiality</li> <li>• Minimize the risk of attacks to the system</li> </ul>
Notes	The extent of the usage of 2FA should be decided after discussing this option with each client and considering the billing plan

Code number	UR_F18
Name	The DSS must provide a guidebook on best practices to the public, based on the experience gained through the system
Stakeholder(s)	All
High level description	This module of the ICARUS DSS will translate the findings of ICARUS project in term of analysis of the effects of the policies and measure analyzed for the participating cities in a <b>web-based guidebook</b> providing also give guidance to other European cities.
Issues and benefits	<ul style="list-style-type: none"> <li>• Information on air quality available to the public</li> <li>• Informing cities that do not currently use the DSS about its capabilities</li> </ul>
Notes	

Code number	UR_F19
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<b>Name</b>	The DSS should support import of spatial databases at the city level
<b>Stakeholder(s)</b>	Decision & policy-making/regulatory bodies, City partners, Academic/Scientific community
<b>High level description</b>	DSS data on an urban scale will mainly derive by the 9 cities participating in the project. This data can be applied to other cities as well with sufficient accuracy. However, the ability of integrating into the models data specific to the geographical entity that is executing the scenarios, will allow for results based on the actual data of the region. This will significantly increase the accuracy of the policy impact simulations.
<b>Issues and benefits</b>	A possible issue of this requirement is that technical expertise may be required to perform such an action and this could also increase the workload for the service provider.  However, importing local data will improve the efficiency of the DSS.
<b>Notes</b>	

<b>Code number</b>	<b>UR_F20</b>
<b>Name</b>	The DSS should support “source apportionment”, the assessment of contribution of different emission sources to the total concentration of different pollutants
<b>Stakeholder(s)</b>	Decision & policy-making/regulatory bodies, City partners, Academic/Scientific community
<b>High level description</b>	Each polluter emits several different pollutants in the atmosphere and almost all of these substances of the substances are emitted by multiple polluters. Since the pollutants are dispersed into the atmosphere, it is almost impossible to study the contribution of each polluter in terms of substance and quantity by only analyzing concentration levels. To this end, source apportionment techniques should be used in each geographical entity, in order to deduce the contribution of each polluter to the overall situation.  This is necessary in order to take measures that will regulate polluters’ emissions according to the nature and quantity of the pollutants they produce. By doing so, the policies will maximize positive impact to air quality while minimizing negative impact to the polluters that have small contribution to the problem.
<b>Issues and benefits</b>	The benefit of using source apportionment techniques is that the DSS can help decision-makers create targeted policies with the least possible interference.
<b>Notes</b>	

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<b>Code number</b>	<b>UR_F21</b>
<b>Name</b>	The DSS could support daily monitoring of the pollutants in an area/region
<b>Stakeholder(s)</b>	Decision & policy-making/regulatory bodies, City partners, Academic/Scientific community  Citizens
<b>High level description</b>	Concentration of pollutants in the atmosphere depends on several factors, such as the weather conditions. As a result, air quality can significantly vary at a daily basis. The DSS could monitor these variations and inform the citizens and the local authorities on their daily values. By doing so, the DSS can improve the reflexes of the authorities in taking emergency measures in case of exceedance, while preventing the citizens of the imminent risk. The latter can help citizens reduce their exposure by avoiding some activities such as outdoor physical exercise.
<b>Issues and benefits</b>	By monitoring daily concentration of pollutants, we can: <ul style="list-style-type: none"> <li>• Help authorities control the situation</li> <li>• Protect citizens from unwanted exposure</li> </ul> Give added value to the user-centric smartphone application
<b>Notes</b>	

<b>Code number</b>	<b>UR_F22</b>
<b>Name</b>	The DSS could provide statistics on annual exceedance of limit values per geographical entity
<b>Stakeholder(s)</b>	Decision & policy-making/regulatory bodies, City partners, Academic/Scientific community  Citizens
<b>High level description</b>	Impact of air quality on public health depends considerably on the exposure of the population to pollutants. When the concentration of the latter exceeds the security limits, it can have negative effects to citizens, especially to those that belong to sensitive groups of the population. Although this is already taken into consideration in the execution of DSS models, it could also be made available to the authorities and the citizens, for informational and sensitizing purposes.
<b>Issues and benefits</b>	Providing annual exceedance statistics will offer the benefits of: <ul style="list-style-type: none"> <li>• Informing the authorities and the public</li> </ul>

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	Evaluate progress in air quality improvement in annual basis
Notes	

Code number	UR_F23
Name	The DSS could help optimize the monitoring network
Stakeholder(s)	Decision & policy-making/regulatory bodies, City partners
High level description	Authorities install a monitoring network for pollutants concentration in a few selected positions. The size and cost of those monitoring stations does not allow either for regular relocation or for a large number of stations. Due to geographical and other factors, mainly related to polluters presence, the values measured by the stations may significantly vary from the actual ones in neighboring areas. This creates the need of careful selection of the positions of monitoring stations. DSS could help authorities select the optimal locations for their network.
Issues and benefits	By optimizing their monitoring network, geographical entities can achieve more representative measurements at lower costs.
Notes	

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### 3.4 Potential sources of information

Various types of information should be processed in the frame of the proposed system, depending on the problem being solved and the level of work. Some of the data is relatively stable, such as type of land use or location and characteristics of some emission sources. Others by their nature are variable and depend on the conditions at the time.

The set of potential types and sources of information is given in Appendix 1: Potential sources of information.

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## 4 Functional specifications

The DSS will provide numerous functionalities to its users, and the availability of each of them will depend on the type of user. Each stakeholder has different needs and purposes; the DSS must take care of this differentiation and provide each one of them with tools addressing their needs. It is therefore crucial to define user roles, match them with the stakeholder groups and clearly specify the features available to each one of them.

The DSS must also be scalable in terms of number of users and of computational resources. To achieve the former, decentralization of the management must be provisioned, so that each geographical entity in the DSS have its own administration and user account management. For the latter, a modular architecture on cloud infrastructure will be used, as it will be specified in the respective deliverable (D7.2). Since the DSS will be a commercial product, special care must be taken in order to make sure that usage is monitored and billing is possible later on.

In this chapter the user roles are defined and matched to the stakeholder groups. The functional specifications are also elaborated through detailed user stories.

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## 4.1 Users roles

The ICARUS DSS will support both registered and unregistered users and will expose different sets of functionalities and features to each user role.

For the registered users, access to the ICARUS DSS will be subjected to authentication of different security levels. In its simplest form, it will be done by user name and password, with user organized in groups with different access rights. Depending on the level of security needed, more secure means of authentication will be offered, such as two-factor authentication through SMS or a mobile application. Access could also be restricted to domains and IP addresses at the level of the web server, in order to further increase security.

### 4.1.1 Master administrator

The master administrator will be the most powerful user role of the ICARUS DSS. It must be assigned to IT professionals that have the knowledge and training to manage such a sophisticated system, with user roles of multiple levels and complex data resources.

The master administrator will have the privileges of:

1. Creating, modifying and deleting user accounts of any type
2. Creating, modifying and deleting geographical entities
3. Define geographical entities
4. Assigning geographical entities to local administrators and other user accounts
5. View usage statistics

### 4.1.2 Accountant

ICARUS DDS is intended to be used by numerous authorities of all levels of administration throughout Europe. It should support several billing options, such as pay-as-you-go, fixed price, by number of users etc. The resources available to each entity must be recorded and possibly regulated according to their usage plan.

The accountant role will:

1. See usage of resources by geographical entities
2. Assign usage plans to the geographical entities
3. Define billing policies

### 4.1.3 Local administrator

The DSS will be used by numerous distinct administrative entities. Furthermore, the size and variety of the data that will be needed by it requires several user accounts for each administrative entity. To effectively manage a system like this, it is highly important to provide a decentralized user

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management mechanism, that will enable the aforementioned entities to autonomously manage their subject user accounts. One or more local administrator accounts will be responsible of performing these tasks for each geographical entity. The master administrator will assign at most one (1) geographical entity per local administrator.

The local administrator role will have the privileges of:

1. Creating, modifying and deleting policy maker and citizen accounts in their geographical entity
2. Manage some of the publicly available information of their jurisdiction
3. View usage statistics related to the users of their jurisdiction
4. View billing information

#### 4.1.4 Policy maker

This is the most important role of the ICARUS DSS, that will use its core functionalities. Policy maker accounts are addressed to the decision makers themselves and any other person involved in the policy planning process.

The policy maker role will have the privileges of:

1. Creating, modifying and deleting policy scenarios based on the available models
2. Access the data concerning their geographical entity
3. Execute scenarios and view the results

#### 4.1.5 Data collector

The collection of emissions or concentrations (or even health related metrics) is a continuous process that makes the DSS a living system. The data collector role can feed the system with new data that is necessary for the next steps of the process. The role may be assigned to third party systems interacting with the DSS to provide new data. Alternatively, a human user may import data files or introduce data using predefined forms.

The user-centric tools run on mobile devices and wearables may play this role when needed, to send collected metrics to the DSS.

#### 4.1.6 Visitor / Public User

In addition to its key role in supporting decision makers of all levels to conclude to effective policies, the DSS also aims to inform and sensitize the public on the evolution of air quality in their areas. To this end, it will host and make publicly available some of the data collected during the project.

A visitor role will thus be foreseen, which will not require registration or login, and will be able to view information on the project's results and on air quality throughout Europe.

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## 4.2 Mapping stakeholders to user roles

In the following table the each user role previously analyzed is mapped to the stakeholder group(s) it corresponds to.

User Roles	Stakeholders
Master administrator	ICARUS DSS team (UPCOM, KartECO, ARTEMIS)
Accountant	ICARUS DSS team (UPCOM, KartECO, ARTEMIS)
Local administrator	<b>City Partners</b> (City partners, Municipalities, Public authorities, Civil protection agencies, Community medical staff, Communal information centres, Investors....), <b>Decision &amp; policy-making/regulatory bodies</b> (Relative Ministries, Municipalities, Politicians, European Commission, European Parliament, European Council), <b>Academic/Scientific community</b> ((University Community (Students & Staff), Researchers, Leading scientific programmes, Scientific networks), <b>Industry &amp; SMEs</b> (Private/commercial sector, Chemical sector, Manufacturing sector, ICT sector, SMEs)
Policy maker	<b>Decision &amp; policy-making/regulatory bodies</b> (Relative Ministries, Municipalities, Politicians, European Commission, European Parliament, European Council), <b>City Partners</b> (City partners, Municipalities, Public authorities), <b>City Partners</b> (City partners, Municipalities, Public authorities, Civil protection agencies, Community medical staff, Communal information centres), <b>Engineering sector</b> (city planners, engineers, architects & designers, environmental professionals), <b>Academic/Scientific community</b> ((University Community Staff), Researchers, Leading scientific programmes, Scientific networks)
Data collector	<b>All stakeholders</b>
Visitor / Public User	<b>All stakeholders</b>

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## 4.3 User stories

### 4.3.1 Visitor / Public user functionality

Identifier	UC1.1
Title	Public user general information
Description	<p><b>As a public (non-logged in) user</b></p> <p><b>I want to</b> view information about air quality in my region</p> <p><b>so that</b> I am better informed</p>
Acceptance Criteria	<ul style="list-style-type: none"> <li>- The public user can view general information about the Icarus project</li> <li>- The public user can view general recommendations for more environmental-friendly activities</li> <li>- The public user can view current pollutant concentrations in the region they are located</li> <li>- The public user can view information on the impact of air quality to public health and well-being</li> <li>- The public user can't access protected areas of the system, without authenticating first</li> </ul>

Identifier	UC1.2
Title	Request access
Description	<p><b>As a public (non-logged in) user</b></p> <p><b>I want to</b> request access to the DSS</p> <p><b>so that</b> I can use functionality reserved to registered users</p>
Acceptance Criteria	<ul style="list-style-type: none"> <li>- The public user can select to register in the Icarus DSS</li> <li>- The user fills in basic demographic information, their e-mail address, first and last name being mandatory</li> <li>- The user selects the region s/he is interested in from a hierarchical list of supported regions (countries, regions, cities)</li> </ul>

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	<ul style="list-style-type: none"> <li>- The user selects the role(s) s/he wants to assume in the DSS</li> <li>- The user submits the information to the system</li> <li>- The system informs the user of the successful submission of the request</li> <li>- The user is not able to submit the form if the mandatory fields are not completed</li> <li>- The user is not able to submit the form if their e-mail address is already in use by another user</li> <li>- Depending on the requested role and the selected region, the system sends the request to the appropriate users to approve/reject the request</li> </ul>
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<b>Identifier</b>	<b>UC1.4</b>
<b>Title</b>	Public user confirmation
<b>Description</b>	<p><b>As a public (non-logged in) user</b></p> <p><b>I want to</b> confirm my registration</p> <p><b>so that</b> I can have access to the restricted functionality</p>
<b>Pre-requisite</b>	<p>The user has already asked for registration approval</p> <p>The local administrative account has approved their request</p>
<b>Acceptance Criteria</b>	<ul style="list-style-type: none"> <li>- The public user receives an e-mail with the confirmation of his/her registration</li> <li>- The user visits the web-page indicated in the mail</li> <li>- The user selects a strong password (to be defined at a system level)</li> <li>- The user re-types the password and confirms the registration</li> <li>- The system informs the user of a successful registration and grants him/her access to the system – with the approved roles</li> <li>- The user does not provide a strong password and the system invites him/her to re-enter a strong password</li> <li>- The user does not enter the same password twice and the system</li> </ul>

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	<p>invites him to retype the passwords</p> <ul style="list-style-type: none"> <li>- The user takes more than 15 minutes to react to the mail received and the system invalidates the confirmation; the user will have to use the Forget Password user story to request a new password</li> </ul>
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<b>Identifier</b>	<b>UC1.5</b>
<b>Title</b>	Public user rejection of confirmation
<b>Description</b>	<p><b>As a</b> public (non-logged in) user</p> <p><b>I want to</b> reject the confirmation to my registration</p> <p><b>so that</b> I show my objection to the access granted to me</p>
<b>Pre-requisite</b>	<p>The user has already asked for registration approval</p> <p>The local administrative account has approved their request</p>
<b>Acceptance Criteria</b>	<ul style="list-style-type: none"> <li>- The public user receives an e-mail with the confirmation of his/her registration, indicating reduced roles to the ones requested by him/her</li> <li>- The user either ignores the mail or visits the registration page and requests new access again!</li> <li>- The user selects a strong password (to be defined at a system level)</li> <li>- The user re-types the password and confirms the registration</li> <li>- The system informs the user of a successful registration and grants him/her access to the system – with the approved roles</li> </ul>

<b>Identifier</b>	<b>UC1.6</b>
<b>Title</b>	Public user login
<b>Description</b>	<p><b>As a</b> public (non-logged in) user</p> <p><b>I want to</b> log in the system</p> <p><b>so that</b> I have access to functionality reserved to registered users</p>
<b>Pre-requisite</b>	The user has already registered to the system

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Acceptance Criteria	<ul style="list-style-type: none"> <li>- The public user can select to log in to the system</li> <li>- The system asks the user to provide their e-mail address and the password selected</li> <li>- The system verifies that the credentials provided are correct and grants access to the user at the restricted area</li> <li>- The user does not provide correct credentials and the system rejects access to the restricted area</li> <li>- All failed efforts are logged and after 3 consecutive failures the user account is blocked and the user has to re-activate it using an activation link that will be sent to their e-mail address</li> </ul>
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Identifier	UC1.7
Title	Public user resets password
Description	<p>As a public (non-logged in) user</p> <p><b>I want to</b> reset my password</p> <p><b>so that</b> I can regain access to functionality reserved for registered users</p>
Pre-requisite	The user has already registered to the system
Acceptance Criteria	<ul style="list-style-type: none"> <li>- The public user can select to reset the password (Forget password functionality)</li> <li>- The system asks the user to provide the e-mail address provided during their registration</li> <li>- The system verifies that the e-mail address provided are correct and if so, it sends a confirmation email to the user, otherwise it invites the user to try again</li> <li>- Reset password form usage is logged and after 3 failed attempts the user has to prove they are human</li> <li>- Upon receiving the email, the user continues from the user story "Public user confirmation"</li> </ul>

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#### 4.3.2 Policy Maker functionality

Identifier	UC2.1
Title	Policy maker evaluates impact of a pre-calculated policy or technological measure
Description	<p><b>As a policy maker</b></p> <p><b>I want to</b> evaluate the impact of a policy or technological measure that has already been calculated</p> <p><b>so that</b> I can decide on the feasibility of the policy or measure</p>
Pre-requisite	<ul style="list-style-type: none"> <li>- The user has already logged in and has the role Policy Maker</li> </ul>
Acceptance Criteria	<ul style="list-style-type: none"> <li>- The user selects the region s/he has access and wants to perform the simulation</li> <li>- The system proposes a list of policies/measures already simulated for the user to select</li> <li>- The user can select a completed simulation</li> <li>- The user can modify some basic parameters of the simulation, such as numeric values</li> <li>- The user can define the geographical extent of the measures application by selecting areas on the map; this can be done for several different parameters by using multiple layers</li> <li>- The system shows the results on the map (highlighting the selected region) for the most recent dates available</li> <li>- If multiple data are produced by the simulation, the user can select which of them are shown on the map, by showing and hiding layers</li> <li>- The user can download the results in numerous formats, such as XML, XLS, CSV and/or PDF (if applicable)</li> <li>- The system shows the date range results are available</li> <li>- The user can select any other date in the date range to view the projected results</li> <li>- The user can select a smaller region to view the results</li> <li>- The user can process the results using geo-spatial tools</li> </ul>

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	<ul style="list-style-type: none"> <li>- The user cannot select a larger than the original region to view the results and s/he is informed accordingly by the system</li> <li>- If no pre-simulated policies/measures are found for the selected region, the system invites the user to create a new simulation (by using the User Story UC2.2)</li> <li>- If results are available only for one date, the user will not be able to select any other date to visualize the results.</li> </ul>
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Identifier	UC2.2
Title	Policy maker evaluates impact of a new policy or technological measure
Description	<p><b>As a</b> policy maker</p> <p><b>I want to</b> evaluate the impact of a policy or technological measure that has not already been calculated</p> <p><b>so that</b> I can decide on the potential efficiency of this policy or measure</p>
Pre-requisite	<ul style="list-style-type: none"> <li>- The user has already logged in and has the role Policy Maker</li> <li>- The user is not covered by the predefined policy/mesures scenarios</li> </ul>
Acceptance Criteria	<ul style="list-style-type: none"> <li>- The user selects the region s/he has access to and wants to perform the simulation for</li> <li>- The user provides data for the new measure or policy by filling in forms or using maps (depending on the measure or policy type, the input method may be different and adapted)</li> <li>- Upon successful completion of the form, the system launches the simulation in the background and informs the user of the successful initiation of the process. The request for simulation is put automatically in the list of requested simulations. The user can continue with other functionalities of the DSS</li> <li>- If the form is not correctly completed, the system informs the user accordingly and invites him/her to correct the mistakes</li> <li>- When the background processing completes and the simulation is ready, the user is informed with an email and the results of the simulation are made available to all interested users as in UC2.1</li> </ul>

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	<ul style="list-style-type: none"> <li>- If an error occurs during the simulation, the user is informed with an email and has the option to edit the request and re-submit it (as described in UC2.3)</li> </ul>
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Identifier	UC2.3
Title	Policy maker modifies previous policy or technological measure and asks for simulation
Description	<p><b>As a</b> policy maker</p> <p><b>I want to</b> evaluate the impact of a new policy or technological measure based on a previous policy or measure</p> <p><b>so that</b> I can decide on the feasibility of the updated policy or measure</p>
Pre-requisite	<ul style="list-style-type: none"> <li>- The user has already logged in and has the role Policy Maker</li> </ul>
Acceptance Criteria	<ul style="list-style-type: none"> <li>- The system shows the list of policies/measures for which the user has already requested simulation, indicating the success or failure of the simulation</li> <li>- The user selects one of them to modify and resubmit for simulation</li> <li>- The user updates the policy/measure; s/he is able to change all input elements, including the policy/measure type and/or region)</li> <li>- Upon successful completion of the form, the system launches the simulation in the background and informs the user of the successful initiation of the process. The request for simulation is put automatically in the list of requested simulations. The user can continue with other functionality of the DSS</li> <li>- If the form is not correctly completed, the system informs the user accordingly and invites him/her to correct the mistakes</li> <li>- When the background processing completes and the simulation is ready, the user is informed with an email and the results of the simulation are made available to all interested users as in UC2.1</li> <li>- If an error occurs during the simulation, the user is informed with an email and has the option to modify the request and re-submit it again</li> </ul>

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Identifier	UC2.4
Title	Policy maker records policies/measures engaged for the region
Description	<p><b>As a</b> policy maker</p> <p><b>I want to</b> record the decision to apply a specific policy/measure for a region</p> <p><b>so that</b> I can latter compare the simulation to actual results</p>
Pre-requisite	<ul style="list-style-type: none"> <li>- The user has already logged in and has the role Policy Maker</li> </ul>
Acceptance Criteria	<ul style="list-style-type: none"> <li>- The system shows the list of policies/measures for which a successful simulation has been performed</li> <li>- The user selects one of them and (optionally) restricts the region it was applied; s/he includes information about the duration of the policy/measure application</li> <li>- The system informs the user for the success of the operation</li> </ul>

Identifier	UC2.5
Title	Policy maker views actual metrics in a region
Description	<p><b>As a</b> policy maker</p> <p><b>I want to</b> view the actual metrics (AQ and CF) for a region</p> <p><b>so that</b> I can decide on other measures/policies to enforce</p>
Pre-requisite	<ul style="list-style-type: none"> <li>- The user has already logged in and has the role Policy Maker</li> </ul>
Acceptance Criteria	<ul style="list-style-type: none"> <li>- The system shows the default region of the user</li> <li>- The user can (optionally) restrict the region to a smaller area</li> <li>- The system shows the actual values of a series of metrics for the area, such as pollutants concentration, emissions and/or health-related data</li> <li>- The user can select which of the data are projected on the map, by showing/hiding data layers</li> <li>- All projected data is shown with recommended limits displayed and visually easily comparable (different colors per data vs limits)</li> </ul>

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Identifier	UC2.6
Title	Policy maker compares actual metrics in a region vs simulated metrics
Description	<p><b>As a</b> policy maker</p> <p><b>I want to</b> compare the actual metrics (AQ and CF) for a region vs previous simulations</p> <p><b>so that</b> I can evaluate the effectiveness of the measures/policies undertaken in the past</p>
Pre-requisite	<ul style="list-style-type: none"> <li>- The user has already logged in and has the role Policy Maker</li> </ul>
Acceptance Criteria	<ul style="list-style-type: none"> <li>- The system shows the default region of the user</li> <li>- The user can (optionally) restrict the region to a smaller area</li> <li>- The system shows the list of policies/measures undertaken by the authorities (see UC 2.5) for the specific region</li> <li>- The user selects one or more of them and then</li> <li>- The system shows the actual values vs the previously simulated data</li> <li>- The user can select which data are projected by showing/hiding layers on the map</li> <li>- Visually, the system colors the differences towards green when the actual values are better than the projected and towards red when the actuals are worse than the projected</li> </ul>

Identifier	UC2.7
Title	Policy maker can optimize the monitoring network of their jurisdiction
Description	<p><b>As a</b> policy maker</p> <p><b>I want to</b> optimize my monitoring network</p> <p><b>so that</b> I can take advantage of the available equipment to the maximum</p>
Pre-requisite	<ul style="list-style-type: none"> <li>- The user has already logged in and has the role Policy Maker</li> </ul>
Acceptance Criteria	<ul style="list-style-type: none"> <li>- The system shows the default region of the user</li> <li>- The user is invited to define the area they want to monitor on a</li> </ul>

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map

- The user can declare the monitoring equipment they have available for their monitoring network, with specifications of each device, such as which pollutants they can measure, what is their sensitivity etc.
- The user can optionally define the location of the existing stations on the map. In this case, they can also define which of the stations could be relocated.
- The system shows on the map the user an optimized plan for the positioning of their monitoring equipment, which takes into consideration the existing stations -if any.

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#### 4.3.3 Data collector functionality

Identifier	UC3.1
Title	Data collector fills in forms with emissions, concentrations or health related data
Description	<p><b>As a</b> data collector</p> <p><b>I want to</b> introduce new metrics to the system</p> <p><b>so that</b> the entire process has fresh data to work on</p>
Pre-requisite	<ul style="list-style-type: none"> <li>- The user has already logged in and has the role Data Collector</li> </ul>
Acceptance Criteria	<ul style="list-style-type: none"> <li>- The system shows the default region of the user</li> <li>- The user selects a specific point in the region to introduce data for</li> <li>- The user selects the type of data to introduce; the following types are currently supported: <ul style="list-style-type: none"> <li>i. Emissions</li> <li>ii. Pollutant concentrations</li> <li>iii. Health-related</li> </ul> </li> <li>- The system shows the appropriate form to complete</li> <li>- The user fills in the form with the data and submits it to the system</li> <li>- The system validates the form and if successful stores the data in the system and informs the user for the success</li> <li>- If the validation fails, the user is informed and invited to correct and re-submit</li> </ul>

Identifier	UC3.2
Title	Data collector corrects already submitted data
Description	<p><b>As a</b> data collector</p> <p><b>I want to</b> correct metrics to the system that I incorrectly introduced</p> <p><b>so that</b> the entire process has correct data to work on</p>

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Pre-requisite	- The user has already logged in and has the role Data Collector
Acceptance Criteria	<ul style="list-style-type: none"> <li>- The system shows the default region of the user</li> <li>- The user selects the specific point in the region to correct the data already introduced</li> <li>- The system shows the appropriate form completed with the originally introduced data</li> <li>- The user fills in the form with the corrected data and submits it to the system</li> <li>- The system validates the form and if successful stores the data in the system and informs the user for the success</li> <li>- If the validation fails, the user is informed and invited to correct and re-submit</li> <li>- The user is not allowed to modify data introduced by other users; the system validates that and informs pro-actively the user</li> <li>- The user may modify data introduced by other users ONLY if the role "Local Administrator" is also assigned to him/her</li> </ul>

Identifier	UC3.3
Title	Data collector deletes already submitted data
Description	<p><b>As a</b> data collector</p> <p><b>I want to</b> delete metrics from the system that I incorrectly introduced</p> <p><b>so that</b> the entire process has correct data to work on</p>
Pre-requisite	- The user has already logged in and has the role Data Collector
Acceptance Criteria	<ul style="list-style-type: none"> <li>- The system shows the default region of the user</li> <li>- The user selects the specific point in the region to delete the data already introduced</li> <li>- The system shows the appropriate form completed with the originally introduced data</li> <li>- The user confirms the desire to delete this data</li> <li>- The system validates the request and if successful stores the data</li> </ul>

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	<p>in the system and informs the user for the success</p> <ul style="list-style-type: none"> <li>- If the validation fails, the user is informed for the error</li> <li>- The user is not allowed to delete data introduced by other users; the system validates that and informs pro-actively the user</li> <li>- The user may delete data introduced by other users ONLY if the role "Local Administrator" is also assigned to him/her</li> </ul>
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<b>Identifier</b>	<b>UC3.4</b>
<b>Title</b>	Data collector imports data files with emissions, concentrations or health related data
<b>Description</b>	<p><b>As a</b> data collector</p> <p><b>I want to</b> introduce new metrics to the system in bulk (via data files)</p> <p><b>so that</b> the entire process has fresh data to work on</p>
<b>Pre-requisite</b>	<ul style="list-style-type: none"> <li>- The user has already logged in and has the role Data Collector</li> </ul>
<b>Acceptance Criteria</b>	<ul style="list-style-type: none"> <li>- The user selects a data file from the local file system to introduce data in the system</li> <li>- The system validates the data file format and if known, stores the data in the system, starts its processing and informs the user for the success</li> <li>- When the data file processing completes, the user is informed via email and is invited to view the results of the import</li> <li>- If the validation fails, the user is informed and invited to correct the data file and re-submit</li> </ul>

<b>Identifier</b>	<b>UC3.5</b>
<b>Title</b>	Data collector views results of data file import
<b>Description</b>	<p><b>As a</b> data collector</p> <p><b>I want to</b> view the results of importing a data file</p> <p><b>so that</b> I am certain that the data in the file has been properly introduced in the system</p>

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Pre-requisite	- The user has already logged in and has the role Data Collector
Acceptance Criteria	<ul style="list-style-type: none"> <li>- The user views the list of import actions s/he has initiated</li> <li>- The system shows the list of data files with the status of processing and the last processing date. The following statuses are supported:               <ul style="list-style-type: none"> <li>i. Processing</li> <li>ii. Import completed successfully</li> <li>iii. Import failed</li> <li>iv. Deleted</li> </ul> </li> <li>- For successfully completed imports, the user is allowed to view the results of the import</li> </ul>

Identifier	UC3.6
Title	Data collector imports a new data file to correct an incorrect submission
Description	<p><b>As a</b> data collector</p> <p><b>I want to</b> re-import a data file</p> <p><b>so that</b> I can correct data introduced by a previous data file in the system</p>
Pre-requisite	- The user has already logged in and has the role Data Collector
Acceptance Criteria	<ul style="list-style-type: none"> <li>- The user views the list of import actions s/he has initiated</li> <li>- For completed imports (successful or failed), the user is allowed to select a new data file to import</li> <li>- After confirming the operation, the system starts the import and lets the user proceed with other DSS functionality</li> <li>- The user is not allowed to re-submit a data file for imports that have not completed or are deleted</li> </ul>

Identifier	UC3.7
Title	Data collector deleted a data file from the system

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Description	<p><b>As a</b> data collector</p> <p><b>I want to</b> delete a data file</p> <p><b>so that</b> I can remove incorrect data introduced by a previous data file in the system</p>
Pre-requisite	<ul style="list-style-type: none"> <li>- The user has already logged in and has the role Data Collector</li> </ul>
Acceptance Criteria	<ul style="list-style-type: none"> <li>- The user views the list of import actions s/he has initiated</li> <li>- For completed imports (successful or failed), the user is allowed to select an import to delete</li> <li>- After confirming the operation, the system starts removing the previously introduced data and lets the user proceed with other DSS functionality</li> <li>- The user is not allowed to delete a data file that has not completed or is already deleted</li> </ul>

Identifier	UC3.7
Title	Data collector introduces metrics to the system via an Application Programming Interface (API)
Description	<p><b>As a</b> data collector (calling party)</p> <p><b>I want to</b> introduce new metrics via an API</p> <p><b>so that</b> I can automatically introduce new metrics in the system</p>
Pre-requisite	<ul style="list-style-type: none"> <li>- The user has already logged in, holds an authentication token and has the role Data Collector</li> </ul>
Acceptance Criteria	<ul style="list-style-type: none"> <li>- The user submits the new data using the API</li> <li>- The system checks the validity of presented data and responds accordingly to the user</li> <li>- If there are validation errors (such as invalid authentication token, user without the Data Collector role, errors in the presented data) the system informs appropriately the calling party</li> </ul>
Note	This User Story may be used by the user-centric tools to provide real-time data to the platform

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Identifier	UC3.8
Title	Data collector receives data from the DSS via an Application Programming Interface (API)
Description	<p><b>As a</b> data collector (calling party)</p> <p><b>I want to</b> receive data from the DSS from an API</p> <p><b>so that</b> I can get informed on air quality in my area</p>
Pre-requisite	<ul style="list-style-type: none"> <li>- The user has already logged in, holds an authentication token and has the role Data Collector</li> </ul>
Acceptance Criteria	<ul style="list-style-type: none"> <li>- The user sends their current location to the system</li> <li>- The system checks if there are air quality data available at the exact location of the user and sends them</li> <li>- The system checks if there are air quality data available for the geographical entity that the user belongs to, if so, it also sends those data to them</li> <li>- If there are validation errors (such as invalid authentication token, user without the Data Collector role, errors in the presented data) the system informs appropriately the calling party</li> </ul>
Note	This User Story may be used by the user-centric tools to provide real-time data to the platform

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#### 4.3.4 Local Administrator functionality

Identifier	UC4.1
Title	Local Administrator creates/updates users for a region
Description	<p><b>As a</b> local administrator</p> <p><b>I want to</b> create a new user or update an existing one for the region I manage</p> <p><b>so that</b> local users do not depend on approvals from the Master Administrator</p>
Pre-requisite	<ul style="list-style-type: none"> <li>- The user has already logged in and has the role Local Administrator for a specific region</li> </ul>
Acceptance Criteria	<ul style="list-style-type: none"> <li>- The user views the list of local users (assigned to this region or sub/region below that one)</li> <li>- The administrator can add a new user by adding the basic information, such as username, email, first name, last name and the region the user has access</li> <li>- The system validates the accuracy of the data, creates the new user and sends the introduction email to the users' email address</li> <li>- The administrator may change the user details at any time; a confirmation mail is sent to the user after such change</li> </ul>

Identifier	UC4.2
Title	Local Administrator approves/rejects user registration request
Description	<p><b>As a</b> local administrator</p> <p><b>I want to</b> approve or reject a user registration request</p> <p><b>so that</b> only legitimate users have access to the system</p>
Pre-requisite	<ul style="list-style-type: none"> <li>- The user has already logged in and has the role Local Administrator for a specific region</li> </ul>
Acceptance Criteria	<ul style="list-style-type: none"> <li>- The user views the list of pending registration requests (requesting access to this region or sub/region below that one)</li> <li>- The administrator validates the data and approves or rejects the request</li> </ul>

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- The system sends the introduction email to the users' email address if approved or a rejection email if rejected

#### 4.3.5 Accountant functionality

Identifier	UC5.1
Title	Accountant views billing information
Description	<p><b>As an</b> accountant</p> <p><b>I want to</b> export billing information for the users</p> <p><b>so that</b> I can create invoices for their actions</p>
Pre-requisite	<ul style="list-style-type: none"> <li>- The user has already logged in and has the role Accountant</li> </ul>
Acceptance Criteria	<ul style="list-style-type: none"> <li>- The user selects a date range for which the billing will be performed</li> <li>- The system indicates the successful start of the execution and lets the user continue with other actions</li> <li>- Upon successful completion of the billing process, the accountant can download a data file with all relevant information necessary for the invoicing of the users</li> </ul>

Identifier	UC5.2
Title	Accountant views usage information
Description	<p><b>As an</b> accountant</p> <p><b>I want to</b> view the usage of the system by the users</p> <p><b>so that</b> I can eventually bill them for their actions</p>
Pre-requisite	<ul style="list-style-type: none"> <li>- The user has already logged in and has the role Accountant</li> </ul>
Acceptance Criteria	<ul style="list-style-type: none"> <li>- The user selects a date range for which the usage information will be displayed; additionally, filters are also available, such as region, user roles, etc.</li> <li>- The system displays the usage information in parts, per billing category (to be defined at a later stage, when the business plan</li> </ul>

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	will be detailed)
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#### 4.3.6 Master Administrator functionality

Identifier	UC6.1
Title	Creation of geographical entities
Description	<p><b>As a</b> master administrator</p> <p><b>I want to</b> create and assign geographical entities</p> <p><b>so that</b> I can decentralize the management of the system and facilitate the billing process</p>
Pre-requisite	<ul style="list-style-type: none"> <li>- The user has already logged in and has the role Master Administrator</li> </ul>
Acceptance Criteria	<ul style="list-style-type: none"> <li>- The user can create a new geographical entity</li> <li>- The user can define its characteristics, such as name and type (city, region, country)</li> <li>- The user can define the surface that this geographical entity corresponds to by defining its borders on a map</li> <li>- The geographical entities can overlap with entities of different types</li> <li>- If the geographical entity under creation overlaps with another one, the system informs the user</li> <li>- The user can cancel the creation process anytime by clicking on a button; they will then be redirected to the previous page</li> <li>- The user can submit their changes by clicking on a button. The system stores the new geographical entity and the user is redirected to the previous page.</li> </ul>

Identifier	UC6.2
Title	Management of geographical entities
Description	<p><b>As a</b> master administrator</p> <p><b>I want to</b> modify and delete geographical entities</p> <p><b>so that</b> I can modify jurisdictions</p>
Pre-requisite	<ul style="list-style-type: none"> <li>- The user has already logged in and has the role Master Administrator</li> </ul>

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Acceptance Criteria	<ul style="list-style-type: none"> <li>- The user can view all geographical entities on a map</li> <li>- The user can filter the geographical entities shown on a map by type (city, region, country)</li> <li>- The user can zoom in and out the map</li> <li>- The user can view all geographical entities on a paginated table</li> <li>- The user can filter geographical entities shown on the table by name and/or type</li> <li>- The user can click on a geographical entity to go to its modification page</li> <li>- On the modification page, the user can modify all the parameters of the geographical entity as defined in the creation process (UC6.1)</li> <li>- On the modification page, the user can view on this page the local administrator(s) and the number of other users assigned to this region</li> <li>- On the modification page, the user can cancel the modification process at any time by clicking on a button; they will then be redirected to the previous page</li> <li>- On the modification page, the user can submit the changes by clicking on a button. If there is no overlap with other geographical entities of the same type, the changes are registered and the user is redirected to the previous page. If there are overlaps, the user is informed accordingly</li> <li>- On the modification page, the user can delete a geographical entity. The system asks for confirmation before proceeding. If a geographical entity is deleted, all user accounts that were assigned to it do NOT get deleted, but they continue existing assigned to no geographical entity from now on.</li> </ul>
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Identifier	UC6.3
Title	Creation of local administrator accounts
Description	<p><b>As a</b> master administrator</p> <p><b>I want to</b> create local administrator accounts</p> <p><b>so that</b> I can control who manages the users of each geographical</p>

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	entity
Pre-requisite	- The user has already logged in and has the role Master Administrator
Acceptance Criteria	<ul style="list-style-type: none"> <li>- The user can initiate the creation of a new local administrator account</li> <li>- The user can define its username (identical to the e-mail address of the person to whom the account will belong), name, surname, phone number and institution of the account under creation</li> <li>- The user can then assign the account under creation to a geographical entity</li> <li>- The user can cancel the process anytime and return to the page they started from</li> <li>- After all data have been provided the user can confirm the creation of the user by clicking a button</li> <li>- The system will check if a user with the same username (e-mail address) already exists.</li> <li>- If the username is not already in use, an activation e-mail is sent to the e-mail address defined as the username of the account</li> <li>- If the username is already taken, an error message informs the user</li> </ul>

Identifier	UC6.4
Title	Creation of accountant accounts
Description	<p><b>As a</b> master administrator</p> <p><b>I want to</b> create accountant accounts</p> <p><b>so that</b> I can control who manages the billing of the system</p>
Pre-requisite	- The user has already logged in and has the role Master Administrator
Acceptance Criteria	<ul style="list-style-type: none"> <li>- The user can initiate the creation of a new accountant account</li> <li>- The user can define its username (identical to the e-mail address of the person to whom the account will belong), name and surname</li> </ul>

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- The user can cancel the process anytime and return to the page they started from
- After all data have been provided the user can confirm the creation of the user by clicking a button
- The system will check if a user with the same username (e-mail address) already exists.
- If the username is not already in use, an activation e-mail is sent to the e-mail address defined as the username of the account
- If the username is already taken, an error message informs the user

Identifier	UC6.5
Title	Management of user accounts
Description	<p><b>As a</b> master administrator</p> <p><b>I want to</b> manage other users' accounts</p> <p><b>so that</b> I can control who can access the system</p>
Pre-requisite	<ul style="list-style-type: none"> <li>- The user has already logged in and has the role Master Administrator</li> </ul>
Acceptance Criteria	<ul style="list-style-type: none"> <li>- The user can view a paginated table of all the users</li> <li>- The user can search among or filter the results by username, name, surname, account type and geographical entity, if applicable</li> <li>- The user can delete any user account</li> <li>- The system asks for confirmation before account deletion</li> <li>- The system informs the master administrator if they are trying to delete the last local administrator of a geographical entity or the last accountant account</li> <li>- The user can click on an entry of the table to go to the modification page of this account</li> <li>- On the modification page the user can modify all the fields of the account that are provided upon an account creation</li> <li>- On the modification page the user can cancel the process by clicking on a button and return to the previous page</li> </ul>

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- On the modification page the user can submit their changes by clicking on a button
- If the user has just changed the username of a user to one that is already in use, the system does not allow the operation and informs the user
- If the user has just removed the last local administrator from a geographical entity, the system warns the user
- After submission the system modifies the user account accordingly and redirects the user to the previous page

Identifier	UC6.6
Title	Importing a spatial database for a specific city
Description	<p><b>As a</b> master administrator</p> <p><b>I want to</b> import large datasets concerning entire cities</p> <p><b>so that</b> I can increase the data on which the system relies for its operations</p>
Pre-requisite	<ul style="list-style-type: none"> <li>- The user has already logged in and has the role Master Administrator</li> </ul>
Acceptance Criteria	<ul style="list-style-type: none"> <li>- The user can view a paginated table of all the users</li> <li>- The user can search among or filter the results by username, name, surname, account type and geographical entity, if applicable</li> <li>- The user can delete any user account</li> <li>- The system asks for confirmation before account deletion</li> <li>- The system informs the master administrator if they are trying to delete the last local administrator of a geographical entity or the last accountant account</li> <li>- The user can click on an entry of the table to go to the modification page of this account</li> <li>- On the modification page the user can modify all the fields of the account that are provided upon an account creation</li> <li>- On the modification page the user can cancel the process by clicking on a button and return to the previous page</li> </ul>

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- On the modification page the user can submit their changes by clicking on a button
- If the user has just changed the username of a user to one that is already in use, the system does not allow the operation and informs the user
- If the user has just removed the last local administrator from a geographical entity, the system warns the user
- After submission, the system modifies the user account accordingly and redirects the user to the previous page

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## 5 Validation of the requirements

On the following page the traceability matrix, that maps the user requirements to user stories, is presented. It is obvious that many of the user requirements need several user stories to be addressed and vice versa, i.e. sometimes a single user story can cover more than one user requirement. It is concluded that a user requirement is covered by the user stories if there is at least one “X” mark in the user requirement’s column.





## 6 Conclusions

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## Appendix 1: Potential sources of information

Group of information	Type of information
Monitoring networks	Location of monitoring station, characteristic of installed equipment, spatial representativeness and methods of measurements.
Measurement results	Short-term and long-term (e.g. annual or multi-annual) validated data series (from monitoring stations and <i>ad hoc</i> measurement campaigns)
	Sets of statistical parameters calculated from measurement results
	Provisional data: results transmitted from automatic monitoring stations in near real time mode (NRT Data).
Air quality assessments	Results of air quality assessments (classification of zones), areas of exceedances for current scenario and other simulated policy scenarios
Modeled air quality	Spatial distribution of air pollution concentrations (historical, current and forecasted), e.g. from mathematical modeling.
Meteorological/climatic information	Meteorological conditions (historical, current).
Land use and emission sources	Land cover and land use (various thematic layers), 3D terrain models
	Location and characteristics of the sources of air pollutants emission (linear e.g. roads, point e.g. industry and areal e.g. municipal heating systems)
	Emission data sets –values of emission of pollutants and Greenhouse gases from individual sources or selected type of sources from defined area.
Scenarios, plans	Information on completed or planned investments, such as air pollution mitigation measures (e.g., air quality plans and programs for the region or zone).

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	Plans of the investments, e.g. introduction of new emission sources or changes in current structure of sources, traffic scenarios.
<b>Population</b>	Distribution and structure of the population, including information about sensitive groups