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Application of ubiquitous public access to-geographic information to an air quality information service

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Foreword

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This document was prepared by Technical Committee ISO/TC 211, *Geographic information/Geomatics*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Rapid urbanization and industrialization have led to a severe deterioration in the atmospheric environments of major cities[1][2]. Air pollutants, which include both naturally occurring and anthropogenic substances, are associated with illness and mortality in humans, and with damage to natural and built environments[3]. However, despite the dedicated actions over the past decades of both international and national organizations to decrease major pollutant emissions, urban air quality continues to worsen, affecting residential environments and harming the health of citizens[4].

Information communication technology (ICT) has contributed to addressing the challenges of improving urban air quality. Sensor networks provide a powerful tool for monitoring air quality in real-time through widely dispersed monitoring stations[5][6]. Portable air pollution sensors, combined with the Global Navigation Satellite System (GNSS) technology, supplement an existing sensor network with enhanced availability and accessibility for monitoring air quality in near real-time[7][8]. Also, spatial data infrastructure (SDI) is established for integrated and interoperable management of air pollutant measurements at national and international levels. For example, INSPIRE, which is the European SDI based upon ISO 19156, defines a framework to access, share, and use air quality data from member countries[9]. The air quality information platform is a bridge between the sensor systems and the citizens. Both web- and mobile-based applications, highly coupled to geographic information systems (GIS), enable citizens to easily obtain air quality information services without spatial or temporal limitations.

As public awareness of urban atmospheric problems has risen, air pollution now has become both an environmental and social problem. Citizens are also encouraged to participate in air quality assessment and environmental governance[10]. These societal and technical changes require a new paradigm to develop an air quality information system and their services. Different from conventional air quality information systems, citizens are no longer only consumers of air quality information, but rather producers of air quality information. For example, a social media service such as a blog, Twitter, and Facebook are now major communication channels for expressing the concern of citizens about urban air quality issues. Social media technology platforms are now regarded as "social sensors" collecting citizens' perceptions of air quality[11][12].

In this document, an air quality information system was developed, referencing ISO 19154. The ubiquitous public access to geographic information (UPA-to-GI) is a geographic information service for the general public to easily access and produce geographic data or information in a ubiquitous computing environment. In this system, the UPA context information model defined in ISO 19154 is employed to systematically associate air quality data from various information sources (e.g. physical sensor measurements, subjective citizen's opinions, and semantic social media data). The UPA context information model is also used to formulate air quality information services, conforming to the citizen's contextual requests.

This document aims to assist the understating of the UPA context information model and to illustrate its application for air quality information services. In this regard, a proof of concept (POC) study was conducted in Seoul, South Korea. The GIS-based air quality information system was designed and implemented to realize a UPA-based air quality information service. Globally, there are widely different approaches to monitor and report air quality. The UPA-based air quality information service model, described in this document, is a sample of all possible examples. However, the underlying idea and concept for designing and implementing the UPA context information model is still helpful to develop other UPA-based air quality information services, conforming to the unique atmospheric and social environments in each nation.

Application of ubiquitous public access to-geographic information to an air quality information service

1 Scope

This document facilitates an understanding of the Ubiquitous Public Access (UPA) context information model, as defined in ISO 19154, to establish a UPA-to-Geographic Information (GI) environment. In addition, this document illustrates how the UPA context information model is designed and implemented to provide an air quality information service from a geographic information system (GIS)-based air quality information system. The UPA context information model for air quality information is only a sample of all possible examples to realize the UPA-to-GI that could satisfy the requirements of ISO 19154.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at https://www.iso.org/obp

3.1
air pollutant
material emitted into the atmosphere either by human activity or natural processes and adversely affecting humans or the environment

[SOURCE: ISO 18158:2016, 2.1.2.1]

3.2
application
manipulation and processing of data in support of user requirements

[SOURCE: ISO 19101-1, 4.1.1]

3.3
context
aspects or properties of an entity that affect the behaviour or expectations of that entity in any given situation

[SOURCE: ISO 19154:2014, 4.4]

3.4
comprehensive air-quality index
CAI
description of the ambient air qualities based on the health risk of air pollution

EXAMPLE The higher CAI values, the greater the level of air pollution.

Note 1 to entry: The index aims to make the public easily understand how polluted overall air quality currently is or how polluted it is forecast to become.

3.5
geographic context awareness
application (3.2) or *service* (3.12) behaviour based on the recognition of user's geographic *context* (3.3)

[SOURCE: ISO 19154:2014, 4.7]

3.6
geographic information
information concerning phenomena implicitly or explicitly associated with a location relative to the Earth

[SOURCE: ISO 19101-1, 4.1.18]

3.7
geographic information service
service (3.12) that transforms, manages, or presents geographic information to users

[SOURCE: ISO 19101-1, 4.1.19]

3.8
geographic information system
GIS
information system dealing with information concerning phenomena associated with location relative to the Earth

[SOURCE: ISO 19101-1, 4.1.20]

3.9
interface
named set of *operations* (3.10) that characterize the behaviour of an entity

[SOURCE: ISO 19119:2016, 4.1.8, modified — Note 1 to entry was deleted.]

3.10
operation
specification of a transformation or query that an object may be called to execute

[SOURCE: ISO 19119:2016, 4.1.10, modified — Notes 1 and 2 to entry were deleted.]

3.11
public access
open access to information sources and/or *services* (3.12) by general public users and professional users alike

[SOURCE: ISO 19154:2014, 4.18]

3.12
service
distinct part of the functionality that is provided by an entity through *interfaces* (3.9)

[SOURCE: ISO 19119:2016, 4.1.12]

3.13
ubiquitous public access
UPA
service (3.12) that enables end-users to have easy and interoperable access to specific types of data, irrespective of their location or access device, and that match their interest criteria

EXAMPLE Linked Geodata Service.

Note 1 to entry: In the example, the Linked GeoData Service is responsible for openly inter-connecting geographic information to external repositories or web resources using a transform to either Resource Description Framework (RDF) or Web Ontology Language (OWL) format.

[SOURCE: ISO 19154:2014, 4.25]

4 Abbreviated terms and symbols

AQI	Air Quality Index
AQMA	Air Quality Mobile Application
AQODP	Air Quality Open Data Platform
AQSDP	Air Quality Social Media Data Platform
CAI	Comprehensive Air Quality Index
CO	Carbon Monoxide
CO_2	Carbon Dioxide
GIS	Geographic Information System
GNSS	Global Navigation Satellite System
ICT	Information Communication Technology
NO_2	Nitrogen Dioxide
0_3	Ozone
PM	Particle Matter
SDI	Spatial Data Infrastructure
SO_2	Sulphur Dioxide
UPA	Ubiquitous Public Access
UPA-to-GI	Ubiquitous Public Access to Geographic Information
WFS	Web Feature Service
WMS	Web Map Service

5 UPA-to-GI environment for air quality information

5.1 Overview

ISO 19154 is a relatively new International Standard from ISO/TC 211, *Geographic information/ Geomatics*, that defines the reference architecture to realize UPA-to-GI environments. The UPA-to-GI environment aims to enable the general user to have easy and seamless access to geographic data and services regardless of their locations and computing devices. Also, the user is no longer just a recipient of geographic information, but also a producer of geographic information. To realize the UPA-to-GI environment, the UPA context information model, which is defined in ISO 19154, gathers and manages geographic context information from varied data sources including the user. Within the interactions between each user and an information system, the context information model is used to characterize a user's situation in relation with geographic information. Thus, the user can access information meeting

their needs in a convenient and interoperable manner. In this document, the high-level design of an air quality information system for the user to easily access air quality in real-time, and to contribute to air quality monitoring data for participating in societal environmental decision making is presented.

5.2 Main components

The air quality information system is built using UPA-to-GI concepts, as shown in Figure 1 and is composed of three fundamental main components:

a) air quality observation system (5.2.1),

b) air quality information platform (5.2.2), and

c) users (5.2.3)

5.2.1 Air quality observation system

The application of ICT to a variety of air quality observation systems has contributed to resolving global air quality challenges. Air quality monitoring stations, connected in sensor networks, directly monitor air pollutants (PM, O_3, NO_2, CO and SO_2) and obtain real-time data from widely dispersed locations. The Air Quality Open Data Platform (AQODP) stores and checks the quality of the data from the monitoring stations. The Air Quality Social Media Data Platform (AQSDP) is another channel to detect air quality issues from events occurring in real-time and reported within social media. The social media data, which social media users share with the public, describes any events or news that influence urban air quality such as a building fire or factory explosion. Furthermore, as public awareness of urban environmental problems has increased, Air Quality Mobile Application (AQMA) running on mobile devices can provide a mechanism for citizens to express their concerns about local air quality issues. The perceptions from the citizens, when combined with air quality data from air quality monitoring stations, will better enable local authorities to shape policies for improving urban air quality.

5.2.2 Air quality information system

In the UPA-to-GI environment, the air quality information platform is a bridge between heterogeneous air quality observation systems and end users. Air quality data from the observation systems are transmitted to the data hub of the platform, where the context information model employs geographic information to define how air quality data are structured and maintained. At the same time, the air quality information is explicitly or implicitly associated with user's contexts. The air quality information services, which consist of air quality information and action tips, are then created according to the user's location, time, and health status. The air quality platform is a basis for developing both web and mobile applications that enable users to easily access air quality information services irrespective of their locations or devices. These applications also allow users to produce air quality data based on their perceptions and opinions, which are submitted to the air quality information platform, as contributed social data.

5.2.3 Users

The main users of the air quality information system are citizens or local authorities. Local authorities will use the air quality information services for policy or operational decision making. For example, the air quality information platform provides locational air quality statistics along with citizens' perceptions of air quality. These data provide a reference by which to recognize knowledge and communication gaps between the citizens and policy makers. The web and mobile applications also convey air quality information services to citizens, allowing them to represent their opinions visually through an easy to understand graphic interface with icons and colours. Citizens can use the services when planning outdoor activities and decisions on where to live or relocate.

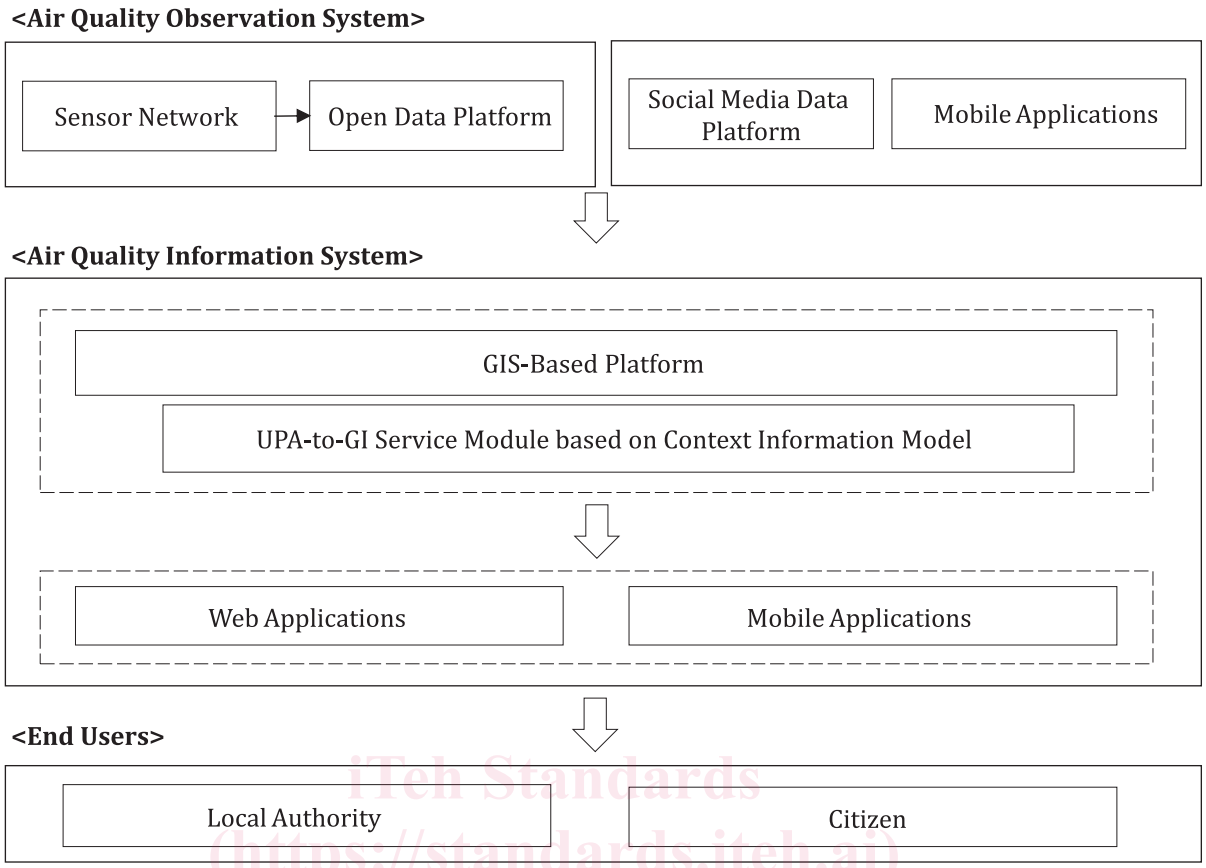

Figure 1 — Main components in UPA-GI based air quality information

5.3 Air quality index

In the UPA-to-GI environment for air quality information, the air quality information platform collects air quality data from the air quality observation systems. The air quality contexts are than extracted and associated with contexts from users to provide relevant air quality information services. The air pollutant measures obtained from the air quality monitoring station are simply numerical data, therefore they are converted into a region-appropriate Air Quality Index (AQI) scheme to help citizens more easily understand air quality levels and to protect their health during episodes of severe air pollution. AQI indicates an overall air quality derived from all air pollutant measurements, as shown in Table 1. The health implications corresponding to index categories are shown in Table 2.

Different countries employ specific air quality indices, corresponding to their respective national air quality standards. This document presents examples using the Comprehensive Air Quality Index (CAI) and behavioural guidelines established for use in the Republic of Korea[13].

Table 1 — Comprehensive air-quality index (CAI)

Pollutant	Good	Moderate	Unhealthy	Very Unhealthy	
				I	II
CAI	0~50	51~100	101~250	251~350	351~500
$PM_{2.5}$ ($\mu g/m^3$)	0~15	16~50	51~100	101~250	251~500
PM_{10} ($\mu g/m^3$)	0~30	31~80	81~150	151~300	301~600
O_3 (ppm)	0~0,030	0,031~0,090	0,091~0,150	0,151~0,500	0,501~0,600
NO_2 (ppm)	0~0,030	0,031~0,060	0,061~0,200	0,201~0,600	0,601~2,000
CO (ppm)	0~2,000	2,001~9,000	9,001~15,000	15,001~30,000	30,000~50,000