INSPIREd Air Quality Reporting

Katharina Schleidt

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European Air Quality e-Reporting Based on INSPIRE

Katharina Schleidt

Umweltbundesamt GmbH, Vienna, Austria,
`Katharina.Schleidt@umweltbundesamt.at`

Abstract. The new Air Quality Directive (2008/50/EC) foresees the provision of air quality reporting data utilizing the data specifications and services specified by the INSPIRE Directive (2007/2/EC). For this purpose, existing INSPIRE data specifications must be extended as required to support the legal requirements for air quality e-Reporting. Both the legal background for air quality reporting and INSPIRE as well as the process for extending the INSPIRE data models as required for air quality e-Reporting are described in this paper.

1   Introduction

The new Air Quality Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe (AQD) foresees the provision of air quality reporting data utilizing the data specifications and services specified by the INSPIRE Directive (2007/2/EC). E-Reporting under the AQD is foreseen to begin with the reporting cycle starting in 2014.

For this purpose, the requirements ensuing from the AQD must be analysed and the appropriate classes from the INSPIRE data specifications that can serve as base classes for AQD e-Reporting must be identified. These INSPIRE base classes must then be extended as required to fulfil all requirements ensuing from the AQD. In addition, mandatory attributes stemming from the INSPIRE data specifications must be integrated with the existing reporting requirements from the AQD.

In this paper, we provide both information on the legal background pertaining to the AQD and INSPIRE, as well as detailing the process required for the extension of the existing INSPIRE based classes to the requirements of e-Reporting under the AQD.

2 Background

2.1 Air Quality Directive and Reporting

2008/50/EC on ambient air quality and cleaner air for Europe.
The Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe entered into force on 11 June 2008. This Directive merges most of existing air quality legislation into a single directive (except for the fourth daughter directive) with no change to existing air quality objectives, repealing the Directives 96/62/EC, 1999/30/EC, 2000/69/EC and 2002/3/EC as well as Decision 97/101/EC.

In the process of defining Directive 2008/50/EC the previous air quality directives where reviewed and streamlined with the following goals:

- Simplify/replace specific reporting obligations on exceedances of information and alert thresholds by a semi-automated exchange based on established near-real-time data exchange mechanism;
- Update and optimize exchange of monitoring data and metadata (current exchange of information under 97/101/EC EoI) to minimize administrative burden by providing data exchange tools; these should enable semi-automated aggregation/cascading and through further Quality Control (QC) provisions and availability of metadata minimize further need for interaction between supplier and user;
- Update and optimize provisions on reporting assessment information (current 2004/461/EC questionnaire) that will enable semi-automated aggregation/cascading of the assessment information regardless of its origin (monitoring, modelling), enabling spatial presentation of assessment and unambiguous links to all other information flows;
- Eliminate any double reporting;
- Reduce administrative burden of Member States (MS), the Commission and European Environment Agency (EEA) by automating tools for checking report consistency etc. (applies to all data-flows);
- Enable faster availability of basic assessment information (provisional monitoring data) at a European scale, even in near real time; information will not be used for compliance purposes, but will enable further and cost-effective public dissemination and provide input to European models supporting national and local assessment and forecasting;
- Replace provisional monthly summer ozone reporting and notifications of alert threshold situations by automated near-real time exchange

For provision of data stipulated by Directive 2008/50/EC, the provisions laid down in Directive 2007/2/EC (INSPIRE) shall be taken into account.

2004/107/EC relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air.
Directive 2004/107/EC is the 4th daughter directive passed under the previous air quality framework directive (96/62/EC) on ambient air quality assessment and management, and the only daughter directive not repealed by 2008/50/EC. The directive sets target values for all the pollutants except mercury, complementing the environmental objectives harmonised in 2008/50/EC.

2011/850/EU Implementing Decision .
As stated in Article 28(2) of Directive 2008/50/EC, the Commission shall determine the additional information to be made available by MS as well as the timescales in which such information is to be communicated. The Commission shall also identify ways of streamlining the way data are reported and the reciprocal exchange of information and data from networks and individual stations measuring ambient air pollution within the MS.

This task has been realised in the form of the Commission Implementing Decision of 12 December 2011 laying down rules for Directives 2004/107/EC and 2008/50/EC of the European Parliament and of the Council as regards the reciprocal exchange of information and reporting on ambient air quality (IPR).

The following data flows have been defined to cover the requirements of 2008/50/EC:

(B) Information on zones and agglomerations (Article 6);

(C) Information on the assessment regime (Article 7);

(D) Information on the assessment methods (Articles 8 and 9);

(E) Information on primary validated assessment data and primary up-to-date assessment data (Article 10);

(F) Information on generated aggregated data (Article 11);

(G) Information on the attainment of environmental objectives (Article 12);

(H) Information on air quality plans (Article 13);

(I) Information on source apportionment (Article 13);

(J) Information on the scenario for the attainment year (Article 13);

(K) Information on measures (Articles 13 and 14);

The annexes of the IPR also provide information on data processing and encoding, mandatory thresholds such as limit and target values, aggregates and statistics to be provided as well as the units of measurement to be used for the provision of data.

2.2   INSPIRE and AQD Data Models

The INSPIRE Directive (2007/2/EC).
The INSPIRE Directive entered into force on the 15th of May 2007. It recognises that Community policy on the environment must aim at a high level of protection taking into account the diversity of situations in the various regions of the Community. The Infrastructure for Spatial Information in the European Community (INSPIRE) should

assist policy-making in relation to policies and activities that may have a direct or indirect impact on the environment.

INSPIRE is based on the infrastructures for spatial information that are created by the MS and that are made compatible with common implementing rules and are supplemented with measures at Community level. These measures should ensure that the infrastructures for spatial information created by the MS are compatible and usable in a Community and trans-boundary context.

The INSPIRE Directive states that infrastructures for spatial information in the MS should be designed to ensure that spatial data are stored, made available and maintained at the most appropriate level; that it is possible to combine spatial data from different sources across the Community in a consistent way and share them between several users and applications. Since the wide diversity of formats and structures in which spatial data are organised and accessed in the Community hampers the efficient formulation, implementation, monitoring and evaluation of Community legislation that directly or indirectly affect the environment, implementing measures should be provided for in order to facilitate the use of spatial data from different sources across the MS. Network services are necessary for sharing spatial data between the various levels of public authority in the Community. Those network services should make it possible to discover, transform, view and download spatial data and to invoke spatial data and e-commerce services.

INSPIRE and Reporting.

While the basic INSPIRE data specifications consciously do not take reporting requirements into account, they are built in such a manner as to allow for extension for reporting purposes. Various environmental reporting obligations were provided as Use Cases to the Thematic Working Groups, and taken into consideration in the definition of the INSPIRE data specifications for relevant themes.

Annex F of the INSPIRE Generic Conceptual Model describes how the INSPIRE data specifications can be extended in order to support other purposes while maintaining the INSPIRE requirements. Thus, data provided using an INSPIRE based extended data specification can be used to fulfil obligations stemming from both INSPIRE as well as a thematic reporting requirement, thus reducing the burden on MS data providers.

However, the inclusion of the explicit reporting concepts directly into the INSPIRE Data Specifications would not be beneficial, as this would increase the legislative burden each time thematic reporting requirements were adjusted. In addition to the necessary modifications of the thematic legislation, changes to the INSPIRE Data Specifications would also be required. Thus, the INSPIRE Data Specifications have been designed in such a manner to provide the core thematic framework, which can then then be extended to also support the additional requirements stemming from reporting requirements.

AQD Data Model.

The AQD e-Reporting data model has been designed based on the INSPIRE data specifications. The UML data models created by the INSPIRE Thematic Working Groups (TWG) have been extended to support all requirements stemming from the IPR; these data models have then been used to generate the AQD e-Reporting schemata. The INSPIRE Annex III data specifications, that are of specific relevance to the provision of air quality data under the AQD, are in the process of finalisation.

At the present time, information on the INSPIRE based AQD e-reporting data model is available only from the EEA Air Quality (AQ) Portal. This information includes UML diagrams, presentations on the data model, a mapping file showing the correspondence between the individual elements of data flows B-G to the data model as well as preliminary XSD schema files.

Further background information is also available from the INSPIRE data specification on Environmental Monitoring Facilities which provides the basis for the AQD e-reporting data model as well as the Guidelines for the use of Observations & Measurements (O&M) and Sensor Web Enablement-related standards in INSPIRE Annex II and III data specification development. While these documents do not specifically cover the AQD e-reporting data model, they provide valuable background information and insights to this specification.

3 Definition of the AQD e-Reporting Data Model

3.1 Data Model Definition Process

In order to achieve full synergies between INSPIRE and the newly defined AQD e-Reporting, it is necessary to define an INSPIRE based data model fulfilling all requirements ensuing from the AQD. The following steps have been identified as necessary for the extension of INSPIRE Data Specifications to reporting requirements:

- Analyze reporting concepts from legal requirements
- Identify relevant INSPIRE Themes
- Identify relevant INSPIRE Feature Types
- Map reporting concepts to INSPIRE Feature Types
  - Direct mapping to attributes possible
  - Direct mapping to associations possible
  - Additional attributes necessary → derive class from INSPIRE
  - If required, define additional classes
  - INSPIRE requires additional attributes → add to reporting guidelines
- Provide Mapping from reporting concepts to (extended) INSPIRE classes

The air quality reporting concepts have been harmonized within Annex II of the Implementing Provisions (2011/850/EU) of the AQD and described as discrete data flows. Data flows B-G are of relevance to INSPIRE, as the data to be provided under these data flows corresponds directly to INSPIRE Themes. The information to be provided under data flows H-K pertain to air quality Plans and Programmes; while the

data models for these data flows are also modelled in accordance with all specifications and requirements from the INSPIRE Directive for simplicity of reporting, there is no direct connection between these data flows and INSPIRE data types. Thus, data flows H-K will not be further discussed in this paper. In addition, in ANNEX II the section (A) Common Data types provides common data types that are referenced and reused by the data flows B-K.

In the table below, a mapping to the INSPIRE Themes identified as relevant to serve as base classes for the implementation of these data flows is provided:

Table 1. Mapping of IPR Data Flows to INSPIRE Themes

AQD e-Reporting Data Flow		INSPIRE Theme
(A)	Common Data types	INSPIRE Base, GML
(B)	Information on zones and agglomerations	III.11. Area management/restriction/regulation zones and reporting units
(C)	Information on the assessment regime	
(D)	Information on the assessment methods	III.7. Environmental monitoring facilities O&M in INSPIRE
(E)	Information on primary validated assessment data and primary up-to-date assessment data	III.7. Environmental monitoring facilities O&M in INSPIRE
(F)	Information on generated aggregated data	III.7. Environmental monitoring facilities O&M in INSPIRE
(G)	Information on the attainment of environmental objectives	I.4. Administrative units
(H)	Information on the air quality plan(s)	
(I)	Quantitative source apportionment	
(J)	Evaluation - Baseline and projection	
(K)	Documentation of measures	

In addition, the following INSPIRE themes are of relevance, as the data specifications either link to elements provided by other institutions under these themes or in turn provide input to them:

I.4. Administrative units

III.5. Human health and safety

III.10. Population distribution — demography

Links to and from the relevant AQD e-Reporting classes must be provided within the data model.

3.2 Extension Examples

The relevant classes from the INSPIRE data specifications must be identified, and the required reporting concepts mapped to these classes. Where necessary, the base classes provided by INSPIRE must be extended with Air Quality reporting specific concepts. This mapping and extension process pertains not only to the spatial information, such as station and zone geometry and metadata; it also covers both primary and aggregated data available for both the station and zone levels, utilizing the Observations and Measurements Standard (ISO 19156) for the provision of measurement data. In other cases, the documentation of reporting relevant concepts must be extended in order to fulfill INSPIRE requirements in addition to those ensuing from the AQD.

In the following sections, we will illustrate this extension process based on the INSPIRE EnvironmentalMonitoringFacility Class and the e-Reporting requirements for air quality stations under IPR data flow D. The diagram below shows the INSPIRE EnvironmentalMonitoringFacility Class as well as an excerpt of the the e-Reporting requirements for air quality stations under IPR data flow D:
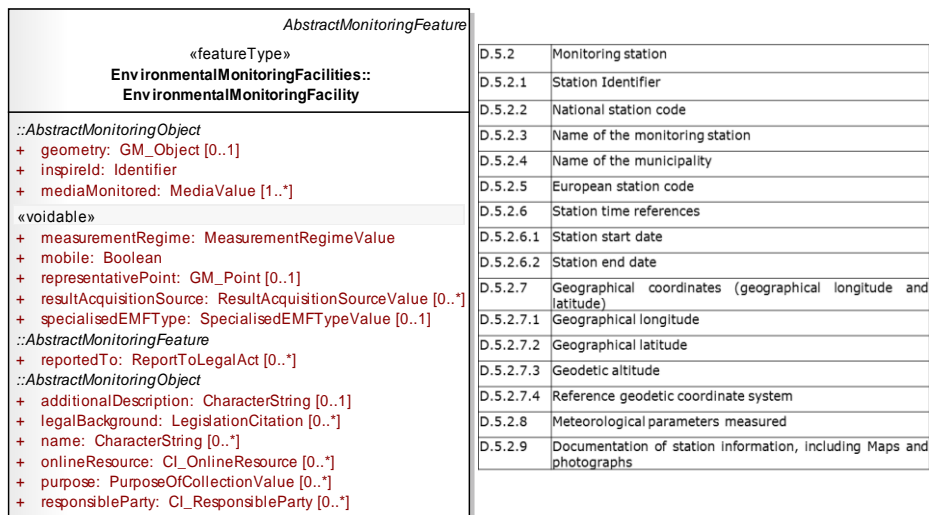

Fig. 1. INSPIRE Class and IPR Requirements

Mapping AQD Requirements to INSPIRE.
In many cases, the classes provided for the specific INSPIRE Themes already possess the necessary attributes for AQD e-Reporting. In the diagram below one can see how various attributes defined for air quality monitoring stations correspond to requirements stemming from the IPR:
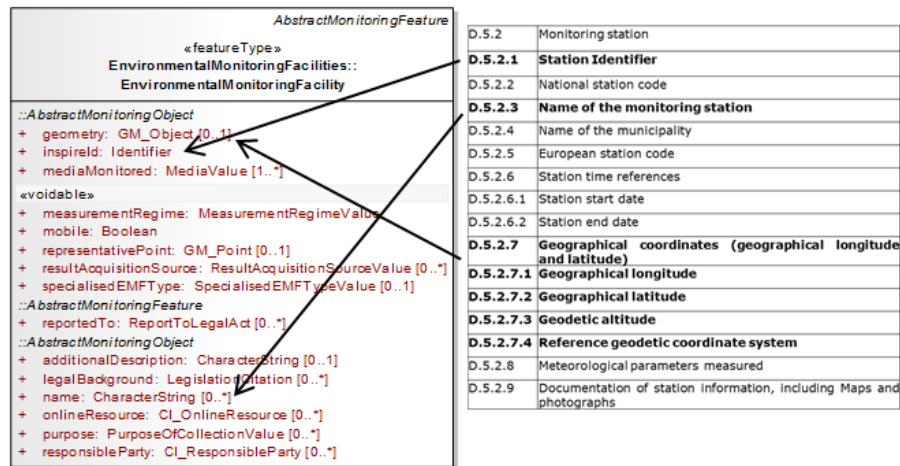
Fig. 2. Mapping of IPR Requirements to INSPIRE Class Attributes

In other cases, the IPR requirements will be mapped to associations between INSPIRE classes. In the example below, we see how the reference to the Air Quality Network a specific Air Quality Monitoring Station belongs to is modeled as the association between the INSPIRE classes EnvironmentalMonitoringFacility and EnvironmentalMonitoringNetwork:
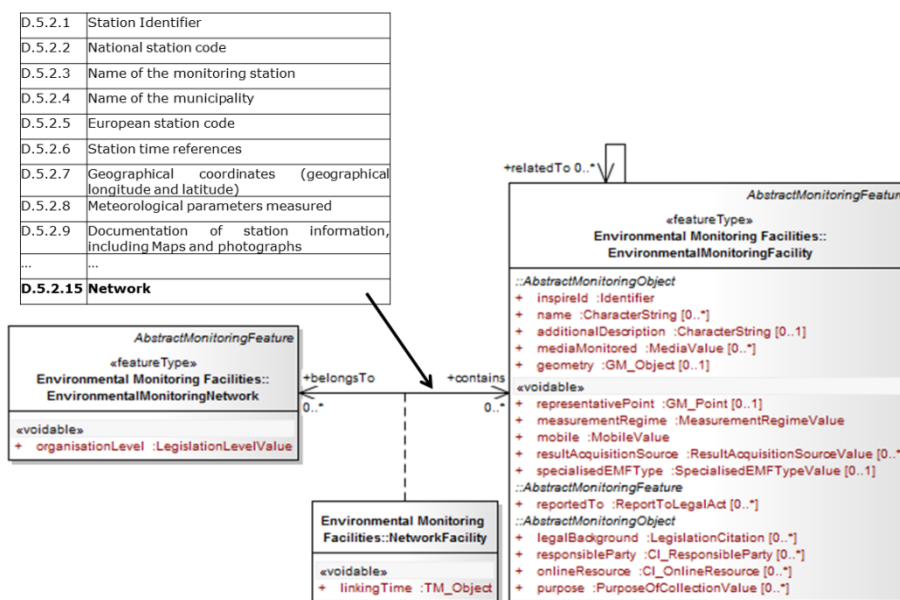

Fig. 3. Mapping of IPR Requirements to INSPIRE Associations

Extending INSPIRE Base Classes.

In certain cases, attributes required for AQD e-Reporting will not be available from the INSPIRE based classes as the INSPIRE classes are defined in a very generic manner and do not encompass all thematic requirements stemming from various environmental domains and usages. In these cases, the additional attributes must be identified, and a new class derived from the basic INSPIRE classes with these additional attributes included. In the example below, the attributes National station code, European station code and Name of the municipality have been identified as additional requirements to the INSPIRE EnvironmentalMonitoringFacility class when using this as a basis for AQD e-Reporting Air Quality Monitoring Stations:
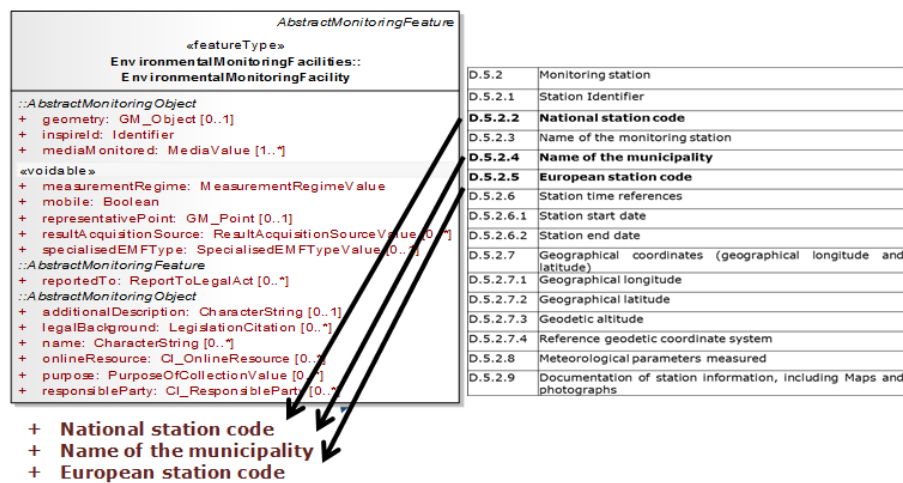

Fig. 4. Extending INSPIRE Classes

A new class AQD_Station must be defined extending the base INSPIRE EnvironmentalMonitoringFacility class as follows:
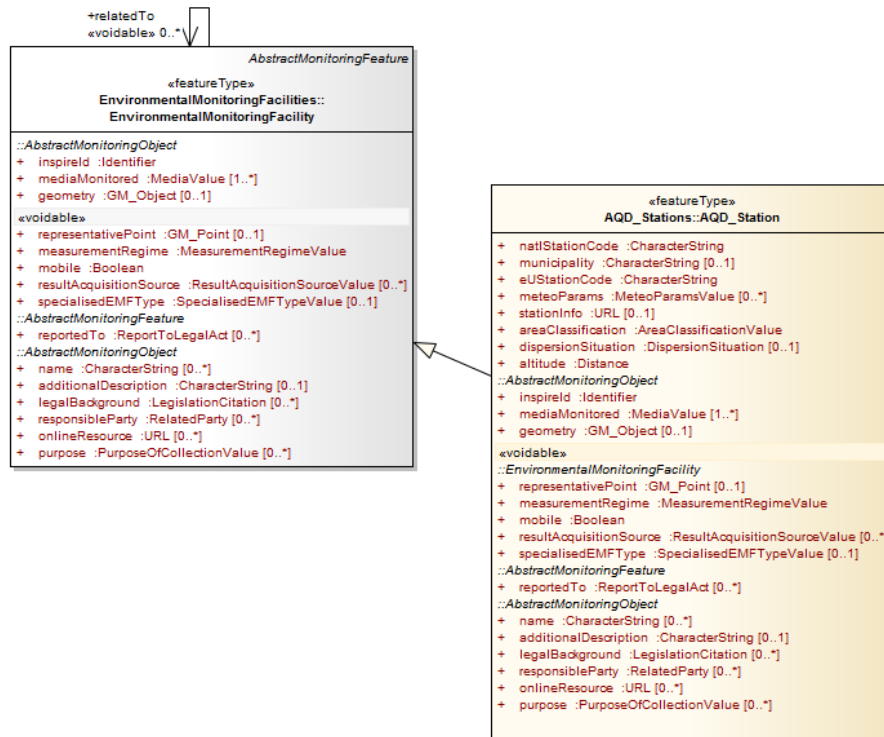

Fig. 5. Deriving an extended INSPIRE Class for AQD e-Reporting

Adding INSPIRE Requirements to Reporting Requirements.

Finally, mandatory attributes stemming from the base INSPIRE data specifications must be identified and added to the reporting requirements. In the example below, the INSPIRE attribute mediaMonitored is appended to the requirements for AQD e-Reporting from the IPR:
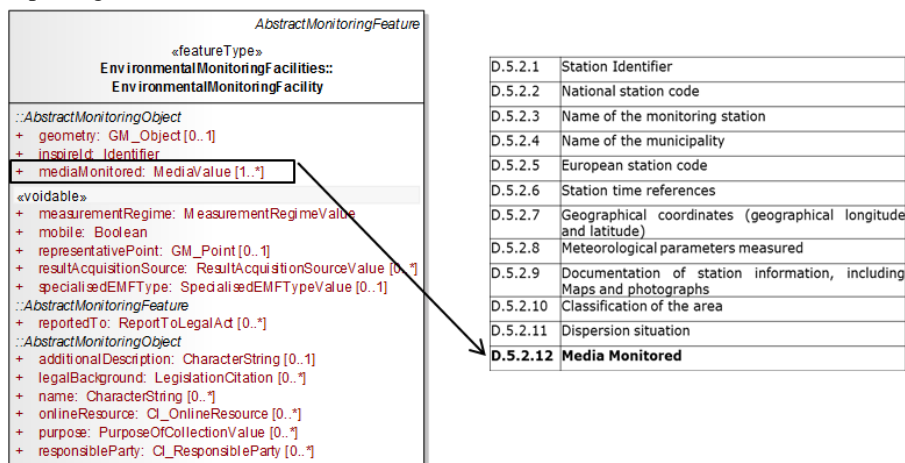

Fig. 6. Extending the AQD Requirements based on INSPIRE

3.3 Mapping from AQD Requirements to e-Reporting Data Model

As a final step in the process of defining an INSPIRE based AQD e-Reporting Data Model, a mapping between the reporting requirements stemming from the IPR to the classes and attributes defined within the data model must be provided. As the air quality responsibles in the MS are familiar with the requirements structure from the IPR, this served as the basis for the mapping tables. For each element in these requirements tables, a mapping to the class and attribute from the AQD e-Reporting Data Model is provided as follows:

Table 2. Mapping from AQD Requirements to Data Model

IPR #	IPR Name	Class	XPATH
D.5.1	Monitoring Station	AQD_Station	/aqd:AQD_SamplingPoint/ef:broader/@xlink:href Linked to /aqd:AQD_Station
D.5.2.1	Station Identifier	AQD_Station	/aqd:AQD_Station/ef:inspireId/base:Identifier
D.5.2.2	National station code	AQD_Station	/aqd:AQD_Station/aqd:natlStationCode
D.5.2.3	Name of the monitoring station	AQD_Station	/aqd:AQD_Station/ef:name

D.5.2.4	Name of the municipality	AQD_Station	/aqd:AQD_Station/aqd:municipality
D.5.2.5	European station code	AQD_Station	/aqd:AQD_Station/aqd:EUStationCode
D.5.2.1	Station Identifier	AQD_Station	/aqd:AQD_Station/ef:inspireId/base:Identifier
D.5.2.6	Station time references	AQD_Station	/aqd:AQD_Station/ef:operationalActivityPeriod/ef:OperationalActivityPeriod

4   Conclusions

Air Quality e-Reporting, as defined in the new Air Quality Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe stipulates the use of INSPIRE for data provision. Thus, an INSPIRE based data model must be created for this purpose. The base classes provided by the various INSPIRE Themes provide the basic building blocks required by reporting for the AQD e-Reporting. However, the base classes provided by INSPIRE will need to be extended to cover the full breadth of reporting requirements. Conversely, the reporting requirements guidelines will need to be extended to cover all INSPIRE requirements.

Through the use of INSPIRE data specifications as a basis for the AQD e-Reporting, great synergies can be attained. Member States only need to set up one INSPIRE service providing relevant Air Quality Features and Data to cover both their INSPIRE obligations as well as their legal reporting obligations pertaining to Air Quality. Air quality data, including both measurement metadata as well as real-time measurement data flows, will be made widely available in a standardized manner allowing for reuse beyond European Reporting obligations.