INSPIRE
Infrastructure for Spatial Information in Europe

D2.9 Guidelines for the use of Observations & Measurements and Sensor Web Enablement-related standards in INSPIRE

Title	D2.9 Guidelines for the use of Observations & Measurements and Sensor Web Enablement-related standards in INSPIRE
Creator	Temporary MIG subgroup for action MIWP-7a
Date of publication	2016-12-16
Subject	Use of Observations & Measurements and Sensor Web Enablement-related standards in INSPIRE
Status	Version 3.0
	This document has been endorsed by the INSPIRE maintenance and implementation group (MIG) in its meeting on 30/11-1/12/2016, *pending a scrutiny reserve from France*[1].
Publisher	INSPIRE Maintenance and Implementation Group (MIG)
Type	Text
Description	This document describes the use of Observations & Measurements and Sensor Web Enablement-related standards in INSPIRE
Format	PDF
Licence	Creative Commons Attribution (cc-by) 4.0 (*https://creativecommons.org/licenses/by/4.0/*)
Identifier	*http://inspire.ec.europa.eu/id/document/tg/d2.9-o&m-swe/3.0*
Corrigenda	Corrigenda to this document will be published at *http://inspire.ec.europa.eu/id/document/tg/d2.9-o&m-swe/3.0/corrigenda*
Language	En

[1] France will submit this document to a national stakeholder consultation (until end of January 2017), as foreseen as an option under the workflow of the MIWP 2014-2016.

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O&M & SWE Guidelines – Executive Summary

While INSPIRE is foremost a Spatial Data Infrastructure, several of the Annex Themes have been specified so that their scope, in addition to the basic spatial information, includes measured, modelled or simulated data. The ISO 19156:2011 standard on Observations and Measurements (O&M) was designed for this explicit purpose, and thus shall be used in INSPIRE to cover these requirements.

The following INSPIRE themes have identified O&M as integrally relevant to their thematic domain and are including elements of O&M into their data specifications:

- **Geology**
- **Atmospheric conditions and Meteorological geographical features**
- **Environmental monitoring facilities**
- **Oceanographic geographical features**
- **SeaRegions**
- **Soil**
- **Species distribution**

In addition to these themes, several further INSPIRE themes have been identified to which observational information, while not at the core of the data specification, is relevant. These themes are:

- **Area management/restriction/regulation zones and reporting units**: Not mentioned but relevant for reporting on aggregated levels
- **Human Health and Safety**: For provision of health determinants
- **Land cover**: Observations form the basis for land cover information
- **Natural risk zones**: Not in the datamodel, but use case “B.5.1 Landslide hazard mapping” states: "Monitoring data: Type of monitoring instrumentation, location of sampling measurements, type and record of measurements"
- **Production and industrial facilities**: Relevant for provision of emissions data for E-PRTR
- **Population distribution - Demography**: StatisticalDistribution, StatisticalValue could easily be mapped to OM_Observation
- **Utility and governmental services**: Highly relevant from a domain perspective. It is currently stated that "Not all the application-specific spatial objects (e.g. flow measurement sensors) are incorporated. Non-geographic data (e.g. information on flow in m^3/s) is also out of scope of this specification"

While the O&M standard provides a generic framework for the provision of measurement data, there are many ways of utilizing the core structures.

In order to ensure compatibility across thematic tailoring versions of the O&M standards, the cross-Thematic Working Group on Observations and Measurements (X-TWG-OM) has provided initial guidelines as to how this standard is to be used within INSPIRE. These guidelines have been be taken into account in the implementation of all INSPIRE themes integrating or referencing to the O&M standard.

They have been further enhanced by the Maintenance and Implementation Work Programme working group for SOS-based download services (MIWP-7a) based on feedbacks from implementations.

Acknowledgements

Many individuals and organisations have contributed to the development of these Guidelines.

The Maintenance and implementation work programme working group for SOS-based download services (MIWP-7a) responsible for these guidelines included: Sylvain Grellet (editor), Gerhard Dünnebeil, Anders Foureaux, Carsten Hollmann, Frédéric Houbie, Diomede Illuzzi, Simon Jirka, Barbara Magagna, Matthes Rieke, Alessandro Sarretta, Katharina Schleidt, Paweł Soczewski, Paolo Tagliolato, Mickael Treguer and Alexander Kotsev, Michael Lutz (European Commission contact points).

The initial cross-Thematic Working Group on Observations and Measurements (X-TWG-OM) set up during annexes II & III data specification process included: Katharina Schleidt (Coordinator), Jandirk Bulens, Simon Cox, Sylvain Grellet, Huibert-Jan Lekkerkerk, Dominic Lowe, Michael Lutz, Clemens Portele, Ilkka Rinne, Heino Rudolf, Laszlo Sores, Jeremy Tandy, Spiros Ventouras, Gavin Walker, Bruce Wright, Alessandro Sarretta (European Commission contact point till May 2012), Tomáš Řezník (European Commission contact point from May till August 2012), Vlado Cetl (European Commission contact point from August 2012)

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Foreword

Directive 2007/2/EC of the European Parliament and of the Council [**INS DIR**], adopted on 14 March 2007 aims at establishing an Infrastructure for Spatial Information in the European Community (INSPIRE) for environmental policies, or policies and activities that have an impact on the environment. INSPIRE will make available relevant, harmonised and quality geographic information to support the formulation, implementation, monitoring and evaluation of policies and activities, which have a direct or indirect impact on the environment.

INSPIRE is based on the infrastructures for spatial information established and operated by the 28 Member States of the European Union. The Directive addresses 34 spatial data themes needed for environmental applications, with key components specified through technical implementing rules. This makes INSPIRE a unique example of a legislative "regional" approach.

To ensure that the spatial data infrastructures of the Member States are compatible and usable in a Community and trans-boundary context, the Directive requires that common Implementing Rules (IR) are adopted in the following areas.

- Metadata;
- The interoperability and harmonisation of spatial data and services for selected themes (as described in Annexes I, II, III of **[INS DIR]**);
- Network Services;
- Measures on sharing spatial data and services;
- Co-ordination and monitoring measures.

The Implementing Rules are adopted as Commission Decisions or Regulations, and are legally binding.

In addition to the Implementing Rules, non-binding Technical Guidance documents describe detailed implementation aspects and relations with existing standards, technologies and practices in order to support the technical implementation process. They may need to be revised during the course of implementing the infrastructure to take into account the evolution of technology, new requirements, and cost benefit considerations. In other words, these Technical Guidance documents are supporting material to assist in the technical implementation of the INSPIRE Directive but no additional obligations can be derived from these documents over and above the obligations set out in the Directive and the Implementing Rules. The Technical Guidance documents are also not intended to interpret legal obligations. Figure 1 illustrates the relationship between the INSPIRE Regulations containing Implementing Rules and their corresponding Technical Guidance documents.

The scope of this document is to provide Technical Guidance for the implementation of the requirements related to the provision of measurement data in INSPIRE, using the ISO Observation and Measurements [ISO 19156] and OGC Sensor Web Enablement standards. Other Technical Guidance exist for the implementation of the requirements for download services using the OGC Sensor Observation Service standard.

Implementing this Technical Guidance are designed to maximise the interoperability of INSPIRE services. Technical Guidance documents describe how Member States might implement the Implementing Rules described in a Commission Regulation. The technical provisions and the underlying concepts are often illustrated by use case diagrams and accompanied by examples. Technical Guidance documents may also include non-binding technical recommendations that should be satisfied if a Member State chooses to conform to the Technical Guidance. However, these recommendations have no legally binding effect.

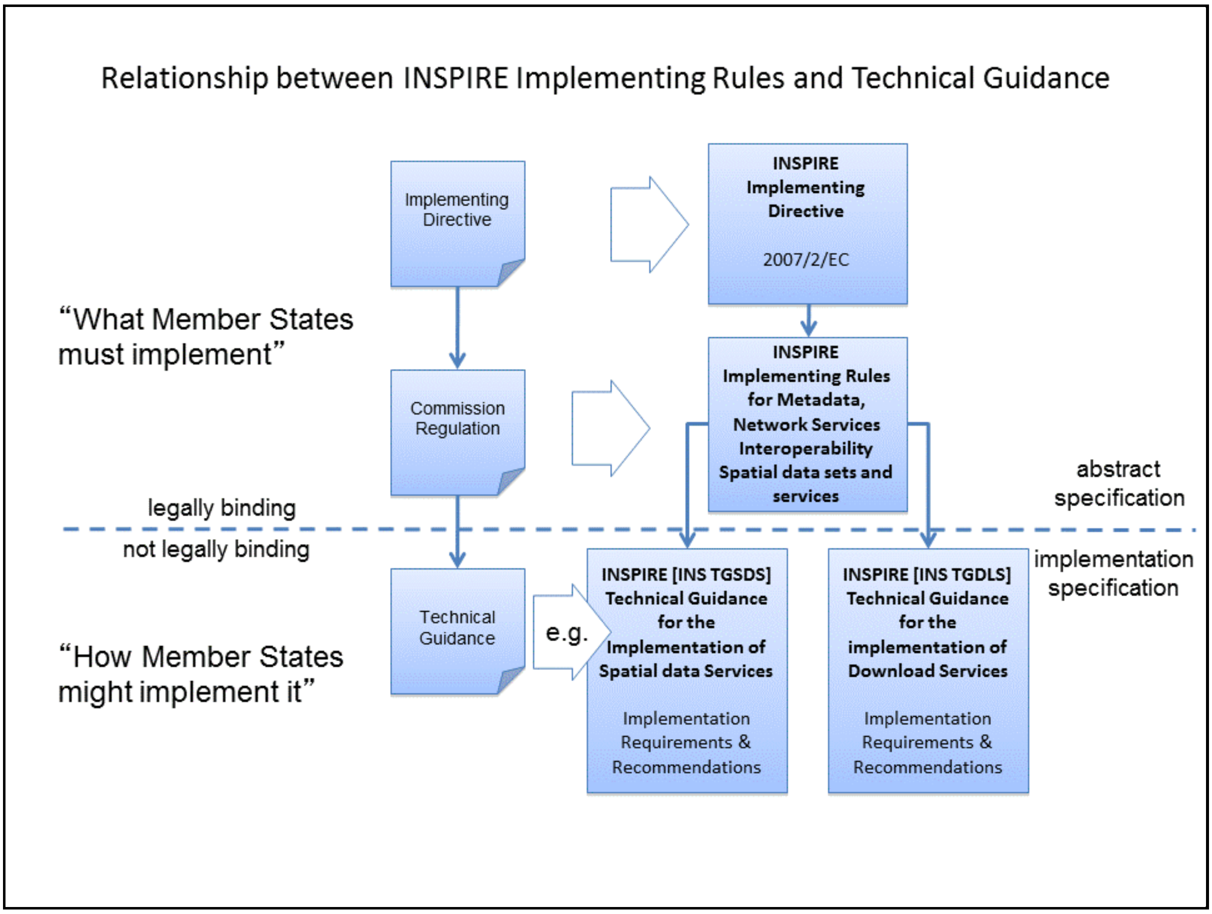


Figure 1: Relationship between the INSPIRE Implementing Rules and the associated Technical Guidance.

Disclaimer

This document has been developed collaboratively through the INSPIRE maintenance and implementation framework, involving experts of the European Commission services, the European Environment Agency, EU Member States, the Accession and EFTA Countries. The document should be regarded as presenting an informal consensus position on best practice agreed by all partners. However, the document does not necessarily represent the official, formal position of any of the partners. To the extent that the European Commission's services provided input to this technical document, such input does not necessarily reflect the views of the European Commission and its services. This document does not bind the Commission and its services, nor can the Commission and its services be held responsible for any use which may be made of the information contained herein.

The technical document is intended to facilitate the implementation of Directive 2007/2/EC and is not legally binding. Any authoritative reading of the law should only be derived from Directive 2007/2/EC itself and other applicable legal texts or principles such as the related Implementing Rules. Only the Court of Justice of the European Union is competent to authoritatively interpret Union legislation.

Requirement classes overview

In this document, requirements classes are provided for 3 target types:
- Logical model: requirement classes '/req/inspire-om-design-patterns' and '/req/inspire-observation-model'
- Data instance: requirement class '/req/inspire-om-core'
- Web services: requirement class '/req/inspire-SOS'

They are organised as follows

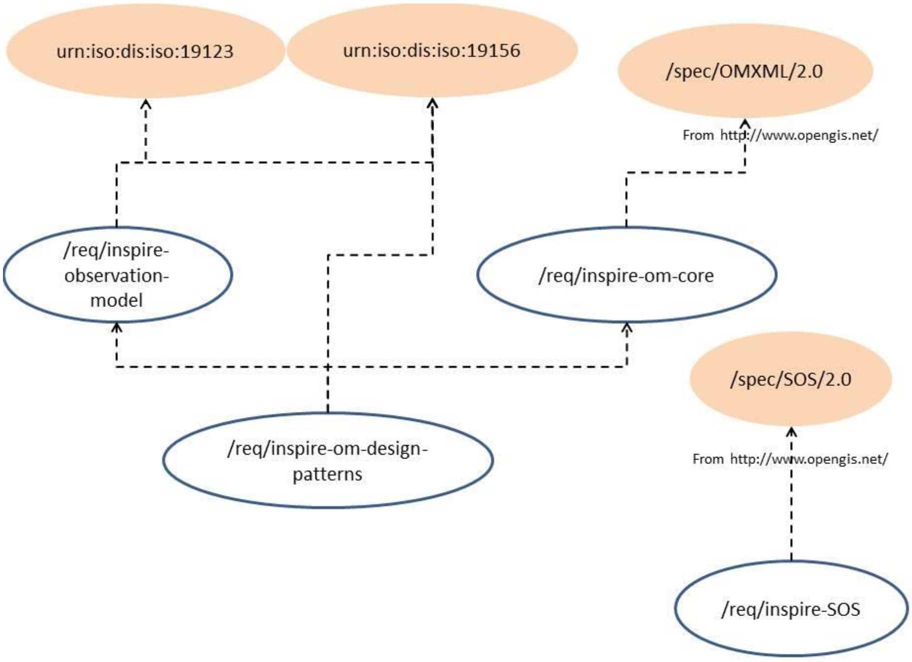


Figure 2 : Requirement classes dependency diagram

1 Scope

The purpose of this document is to provide guidelines on how Observations & Measurements and the OGC Sensor Web Enablement framework are to be used to deliver observation data in the context of INSPIRE.

It does not aim at specifying domain specific (ex: Inspire theme) issues but focuses on observation data and their delivery.

In order to ease its reading and implementation and maximize its reuse this revised version now follows the OGC modular specification (OGC 08-131r3).

2 Conformance

This document provides requirements for the use of Observations & Measurements and Sensor Web Enablement-related standards in the environmental media observation context.

Requirements for three standardization target types are considered:

- Logical model,
- Data instance,
- Web services.

3 References

The following normative documents contain provisions that, through reference in this text, constitute provisions of this document. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the latest edition of the normative document referred to applies.

3.1 Normative references

INSPIRE Directive, **INS DIR**, Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE) [INS DIR]

INSPIRE Network Services Regulation, **INS NS**, COMMISSION REGULATION (EU) No 976/2009 of 23 November 2010 as amended by Regulation (EC) No 1088/2010 as regards download services and transformation services

INSPIRE Regulation on the interoperability of spatial data sets and services Regulation, **INS ISSDS,** COMMISSION REGULATION (EU) No 1089/2010 of 23 November 2010 implementing Directive 2007/2/EC of the European Parliament and of the Council as regards interoperability of spatial data sets and services

ISO 19115:2003, *Geographic information — Metadata*

ISO 19115:2003/Cor 1:2006, *Geographic information — Metadata — Corrigendum 1*

ISO 19123:2005, *Geographic information — Schema for coverage geometry and functions*

ISO 19136:2007, *Geographic information — Geography Markup Language v3.2 (OGC Document 07-036)*

ISO 19156:2011, *Geographic information — Observations and measurements* OGC Abstract Specification Topic 20. OGC 10-004r3 and ISO 19156:2011.

ISO/IEC 19505-2:2012, *Information technology — Object Management Group Unified Modeling Language (OMG UML) — Part 2: Superstructure*

Observations and Measurements - XML Implementation. (OGC 10-025r1). Simon Cox. Wayland, MA, USA, Open Geospatial Consortium Inc.

OGC Coverage Implementation Schema (OGC 09-146r2), Peter Baumann. Wayland, MA, USA, Open Geospatial Consortium Inc.

OGC Implementation Specification: Sensor Model Language (SensorML) SensorML Encoding Standard, version 1.0 Schema - Corrigendum 1. SensorML 1.0.1 (OGC 07-122r2).Mike Botts and Alexandre Robin (2007). Wayland, MA, USA, Open Geospatial Consortium.

OGC Implementation Standard: Sensor Observation Service (SOS) 2.0 (OGC 12-006). Arne Bröring, Christoph Stasch and Johannes Echterhoff (2012).Wayland, MA, USA, Open Geospatial Consortium.

OGC Implementation Standard: WaterML 2.0: Part 1 - Timeseries (OGC 10-126r4). Peter Taylor (2012). Wayland, MA, USA, Open Geospatial Consortium.

OGC Sensor Observation Service 2.0 Hydrology Profile (OGC 14-004r1). Volker Andres, Simon Jirka, Michael Utech (2014). Wayland, MA, USA, Open Geospatial Consortium.

OGC SWE Common Data Model Encoding Standard (OGC 08-094r1). Alexandre Robin. Wayland, MA, USA, Open Geospatial Consortium Inc.

OGC SWE Service Model Implementation Standard (OGC 09-001). Johannes Echterhoff (2011). Wayland, MA, USA, Open Geospatial Consortium.

3.2 Technical references

EU Ambient Air Quality reporting DataModel. *http://www.eionet.europa.eu/aqportal*

INSPIRE *Technical Guidance for implementing download services using the OGC Sensor Observation Service and ISO 19143 Filter Encoding. [INS SOS]*

INSPIRE Technical Guidance for the implementation of INSPIRE Download Services using WCS

INSPIRE *D2.8.III.7 INSPIRE Data Specification on Environmental Monitoring Facilities – Technical Guidelines*

New Zealand Environmental Observation Data Profile - Core, V1.0. Alistair Richie, LandCareResearch. Last consulted 09/06/2016.

4 Terms and Definitions

This document uses the terms defined in Sub-clause 5.3 of [OGC 06-121r9], which is based on the ISO/IEC Directives, Part 2, Rules for the structure and drafting of International Standards. In particular, the word “SHALL” (not “must”) is the verb form used to indicate a requirement to be strictly followed to conform to this standard.

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

(1) **application schema**
conceptual schema for data required by one or more applications [ISO 19101]

(2) **coverage**
spatial object that acts as a function to return values from its range for any direct position within its spatial, temporal or spatiotemporal domain, in accordance with ISO 19123:2007 [INS ISDSS]

EXAMPLE Orthoimage, Image time series, digital elevation model (as grid or TIN), point grids etc.

NOTE In other words, a coverage is a feature that has multiple values for each attribute type, where each direct position within the geometric representation of the feature has a single value for each attribute type.

(3) **data type**
specification of a value domain with operations allowed on values in this domain [ISO/TS 19103:2005, definition 4.1.5]

EXAMPLE Integer, Real, Boolean, String, Date (conversion of a date into a series of codes).
NOTE Data types include primitive predefined types and user-definable types. All instances of a data type lack identity. [ISO 19156:2011]

(4) **domain feature**
feature of a type defined within a particular application domain

NOTE This may be contrasted with observations and sampling features, which are features of types defined for cross-domain purposes. [ISO 19156:2011(E)]

(5) **Ex-situ**
referring to the study, maintenance or conservation of a specimen or population away from its natural surroundings

NOTE Opposite of in-situ.

[ISO 19156:2011(E)]

(6) **feature**
abstraction of real-world phenomena [ISO 19101:2002, definition 4.11]

NOTE 1 A feature may occur as a type or an instance. In this document, feature instance is meant unless otherwise specified. [ISO 19156:2011(E)]

NOTE 2 In INSPIRE, features are referred to as "spatial objects"

(7) **Feature type**
class of **features** having common characteristics [ISO 19156:2011(E)]

(8) **GML application schema**
application schema written in XML Schema in accordance with the rules specified in ISO 19136:2007 [ISO 19136:2007]

(9) **Measure**
value described using a numeric amount with a scale or using a scalar reference system [ISO 19136:2007, definition 4.1.41]

(10) **Measurement**

set of operations having the object of determining the **value** of a quantity [ISO/TS 19101-2:2008, definition 4.20]

(11) **Observation**
act of measuring or otherwise determining the **value** of a **property** [ISO 19156:2011(E)]

(12) **Observation procedure**
method, algorithm or instrument, or system of these, which may be used in making an **observation** [ISO 19156:2011(E)]

(13) **Observation protocol**
combination of a sampling strategy and an **observation procedure** used in making an **observation** [ISO 19156:2011(E)]

(14) **Observation result**
estimate of the **value** of a **property** determined through a known observation procedure [ISO 19156:2011(E)]

(15) **Property**
facet or attribute of an object referenced by a name [ISO 19143:2010, definition 4.21]

EXAMPLE Abby's car has the colour red, where "colour red" is a property of the car instance [ISO 19156:2011(E)]

(16) **Property type**
characteristic of a **feature type**

EXAMPLE cars (a feature type) all have a characteristic colour, where "colour" is a property type

NOTE 1 The value for an instance of an observable property type can be estimated through an act of observation

NOTE 2 In chemistry-related applications, the term "determinand" or "analyte" is often used.

[ISO 19156:2011(E)]

(17) **Sampling feature**
feature which is involved in making **observations** concerning a **domain feature**, this feature provides the direct context for the specific observation (spatial, specimen)

EXAMPLE station, transect, section or specimen.

NOTE A sampling feature is an artefact of the observational strategy, and has no significance independent of the observational campaign.

[ISO 19156:2011(E)]

(18) **Spatial sampling feature**
a sampling feature with a spatial coverage. Used for observations where the result varies within the scope of the feature

EXAMPLE ShipsTrack, Profile, Swath.

NOTE A spatial sampling feature is an artefact of the observational strategy, and has no significance independent of the observational campaign.

(19) **Specimen**
A Specimen is a physical sample, obtained for observation(s) carried out ex situ, sometimes in a laboratory. [ISO 19156:2011(E)]

(20) **Value**
element of a type domain [ISO/IEC 19501:2005]

NOTE 1 A value considers a possible state of an object within a class or type (domain).

NOTE 2 A data value is an instance of a datatype, a value without identity.

NOTE 3 A value can use one of a variety of scales including nominal, ordinal, ratio and interval, spatial and temporal. Primitive datatypes can be combined to form aggregate datatypes with aggregate values, including vectors, tensors and images.

[ISO 19156:2011(E)]

5 Conventions

5.1 Conceptual schemas

Conceptual schemas in the normative part of this Standard are presented in the Unified Modeling Language (UML). UML diagrams are presented in compliance with ISO/IEC 19505-2.

5.2 Requirements class

Each normative statement (requirement or recommendation) in this standard is a member of a requirements class. Each requirements class is described in a discrete clause or sub-clause, and summarized using the following template:

Requirements class	**/req/{classM}**
Target type	[artefact or technology type]
Name	Human readable name of the Requirement Class
Dependency	[identifier for another requirements class]
Requirement	/req/{classM}/{reqN}
Recommendation	/rec/{classM}/{recO}
Requirement	/req/{classM}/{reqP}
Requirement /Recommendation	[repeat as necessary]

All requirements in a class must be satisfied. Hence, the requirements class is the unit of re-use and dependency, and the value of a Dependency requirement is another requirements class. All requirements in a dependency must also be satisfied by a conforming implementation. A requirements class may consist only of dependencies and introduce no new requirements.

5.3 Requirement

All requirements are normative, and each requirement is presented using the following templates.
Either :

/req/[classM]/[reqN]	[Normative statement]

where /req/[classM]/[reqN] identifies the requirement.

or

/rec/[classM]/[recN]	[Informative statement]

where /rec/[classM]/[reqN] identifies the recommendation.

The use of this layout convention allows the normative provisions of this Standard to be easily located by implementers.

5.4 Abbreviations

FoI	Feature of Interest
GML	Geography Markup Language
O&M	Observations and Measurements
OGC	Open Geospatial Consortium
SensorML	Sensor Model Language
SOS	Sensor Observation Service
SWE	Sensor Web Enablement
UML	Unified Modeling Language
WFS	Web Feature Service
XML	Extensible Markup Language

6 Observation models in INSPIRE

6.1.1 Use of O&M vs. Coverage Model

Many types of spatial data can be structured using either O&M or GML coverages. As an initial step one must determine which model to follow for specifying the data models. In certain cases, often pertaining to coverage results, the result is of primary interest while the methodology used in attaining this result is secondary. In other cases, while the result is still of importance, a good understanding of the process that was utilized in generating these results is of utmost importance in proper further utilization of the result data.

Differentiation in a Result/Coverage-centric vs. an Observation-centric view helps determine if a specific type of data should be encoded via O&M observations or GML coverages.

Requirements class	**/req/inspire-observation-model**
Target type	Logical model
Name	INSPIRE observation model identification
Dependency	urn:iso:dis:iso:19156:clause:7.1
Dependency	urn:iso:dis:iso:19123:clause:5
Recommendation	/rec/inspire-observation-model/coverage-centric-view
Recommendation	/rec/inspire-observation-model/observation-centric-view

6.1.2 Result/Coverage-centric view

In the Result/Coverage-centric view, the result (generally a coverage in this case) is the primary object of interest while the description of the observation process is just metadata of the result.
In this view:

- "First class citizens" are coverages
- "Second class citizen", the description of the observation act, can be described as metadata about the coverage.

In this context, it is even possible to envision design patterns that forgo provision of procedural information entirely as this in not of further relevance for the interpretation of the result.

/rec/inspire-observation-model/coverage-centric-view	If a Result/Coverage-centric view is best suited for exchanging information on a specific domain, then O&M is not relevant for this purpose. Information exchange implementation SHOULD conform to "ISO 19123:2005 Geographic information – Schema for coverage geometry and functions", OGC Coverage Implementation Schema and the recommendations contained in the "Technical Guidance for the implementation of INSPIRE Download Services using WCS".

<u>*Note:*</u>
In the context of INSPIRE a dedicated "Technical Guidance for the implementation of INSPIRE Download Services using WCS"provides additional requirements and recommendations.

6.1.3 Observation-centric view

In the Observation-centric view, full knowledge of the result acquisition process is necessary: the explicit relationships between the result and the feature of interest, sampling feature, procedure etc. This

knowledge must be provided to ensure proper (re)use of the result.
In this view:
- "First class citizens" is the description of the observation act. Richness in the properties and description of the observation process is required.
- "Second class citizen", the result, is associated to the observation.

/rec/inspire-observation-model/observation-centric-view	If an observation-centric view is best suited for exchanging information on a specific domain, then "ISO 19156:2011 International Standard on Observations and Measurements" (O&M) and OGC SWE are relevant for this purpose Information exchange implementation SHOULD conform to O&M, apply OGC SWE, and the recommendations contained in the current document.

Note:
In the context of INSPIRE a dedicated "Technical Guidance for implementing download services using the OGC Sensor Observation Service and ISO 19143 Filter Encoding" provides additional requirements and recommendations.

6.2 O&M Design Patterns

Requirements class	**/req/inspire-om-design-patterns**
Target type	Logical model
Name	INSPIRE O&M design patterns
Dependency	/req/inspire-observation-model
Dependency	/req/inspire-om-core
Dependency	urn:iso:dis:iso:19156:clause:7.2.2
Dependency	urn:iso:dis:iso:19156:clause:8
Dependency	urn:iso:dis:iso:19156:clause:9
Dependency	urn:iso:dis:iso:19156:clause:10
Dependency	urn:iso:dis:iso:19156:clause:11
Dependency	urn:iso:dis:iso:19156:clause:D.3.4
Recommendation	/rec/inspire-om-design-patterns/main
Recommendation	/rec/inspire-om-design-patterns/pointObservation
Recommendation	/rec/inspire-om-design-patterns/pointTimeSeriesObservation
Recommendation	/rec/inspire-om-design-patterns/multiPointObservation
Recommendation	/rec/inspire-om-design-patterns/profileObservation
Recommendation	/rec/inspire-om-design-patterns/trajectoryObservation
Recommendation	/rec/inspire-om-design-patterns/gridObservation
Recommendation	/rec/inspire-om-design-patterns/gridSeriesObservation
Recommendation	/rec/inspire-om-design-patterns/specimenObservation
Recommendation	/rec/inspire-om-design-patterns/specimenTimeSeriesObservation

In order to guide the application of O&M, different design patterns fully embracing the richness of the standard have been identified. Each of them is introduced in the following chapter by way of an example and the corresponding specialised observation type to be used.

The detailed specialised observations feature catalogue is available in "Annex B: INSPIRE specialised observations".

/rec/inspire-om-design-patterns/main	O&M design patterns described in this document SHOULD be applied if an observation-centric view is best suited for exchanging information However, in case those design patterns can't be applied because of domain specificity, domain specific O&M design patterns and corresponding UML model, encoding, conformance and conformance classes SHOULD be defined.

6.2.1 Decision Tree

The following decision tree provides a support in the determination of the correct design pattern to use for a specific use case. Each design pattern leads to a specialised observation.
The final nodes of the decision tree (light green) provide the name/id of the design pattern to refer to within the rest of the document.

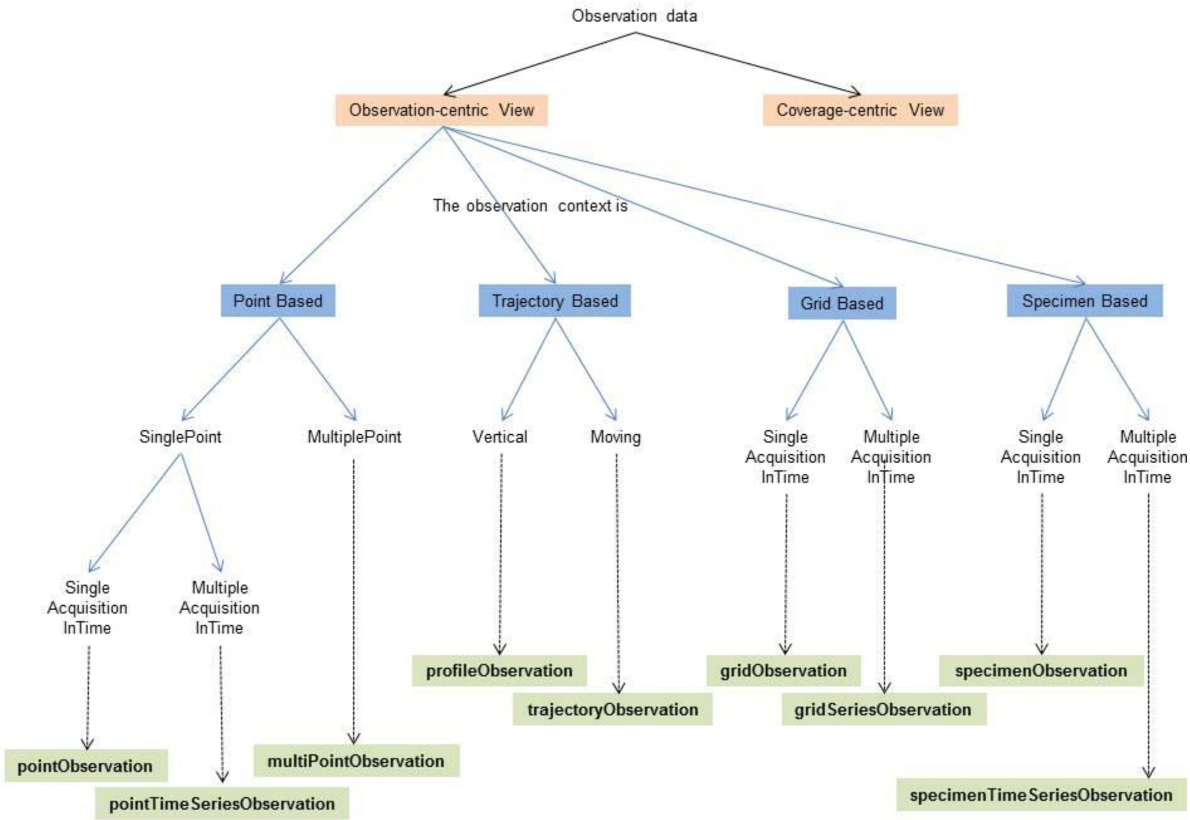


Figure 3: Observation-centric view decision tree to specialised observation type

6.2.2 Point based observation

6.2.2.1. PointObservation

A first example of such case could be the measurement of the height of a given tree, the featureOfInterest being defined as a “species occurrence point”.
The ‘PointObservation’ specialised observation provides the necessary artifact to exchange such information.

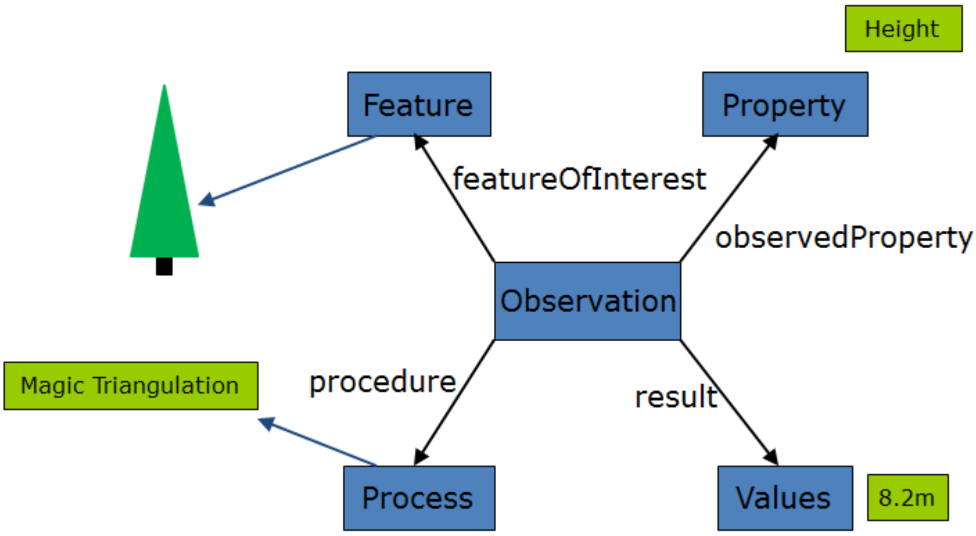


Figure 4 : PointObservation – schematic example

/rec/inspire-om-design-patterns/pointObservation	When the Observation represents a measurement of a property at a single point in time and space the specialised observation ‘PointObservation’ SHOULD be used.

PointObservation class diagram is introduced in the figure below.
“Table 1 : Point Observation – example content description” right after provides a description on how each information element is to be provided.

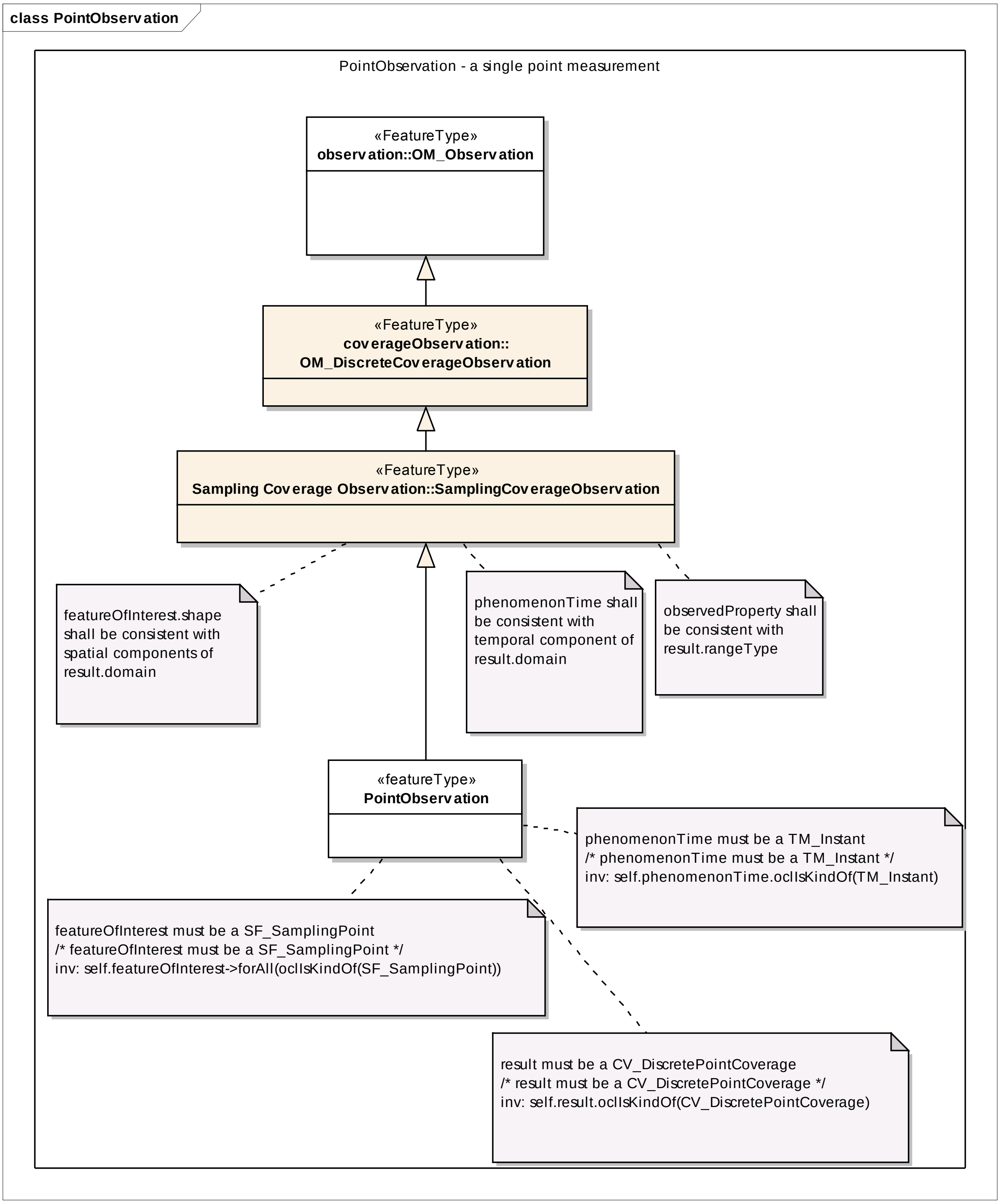


Figure 5 : PointObservation – class diagram

O&M Attribute/association	Example content description
processUsed	Process instance providing information about the responsible party, documented process etc. *See chapter 7.1.4 Procedure.*
featureOfInterest	A *SF_SamplingPoint* at the geographic location of the measurement
phenomenonTime	A time instant e.g. 2012-01-30T10:30:00.00Z (in ISO 8601 including time zone). *See chapter 7.1.1 Observation.*

observedProperty	Link to a vocabulary defining species height. *See chapter 7.1.2 Observed property.*
result	Single valued coverage recording an estimate of the observed property (e.g. 8.2) and the unit used in the result (e.g. Meter).
resultTime	The time the result was made available (e.g. published). *See chapter 7.1.1 Observation.*

Table 1 : Point Observation – example content description

6.2.2.2. Point TimeSeries Observation

An example of such case could be an air quality monitoring station providing ozone concentration measurements. The featureOfInterest represents the direct surrounds of the air intake (i.e. the air bubble surrounding the air intake). The location for the measurements is provided through this featureOfInterest.
As this design pattern usually provides a time series (temporal coverage) result, the explicit phenomenonTime and/or resultTime will often be provided together with the result values.

The ‘PointTimeSeriesObservation’ specialised observation provides the necessary artifact to exchange such information.
Note that such design patterns also apply for repeated manual measurements at a fixed location in space, as well as automated measurements with an irregular measurement interval.

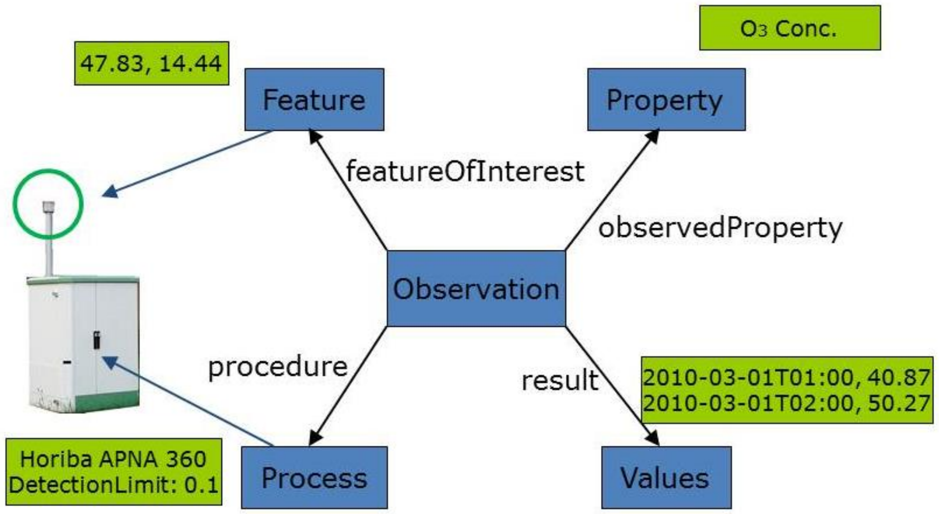


Figure 6 : Point TimeSeries Observation – schematic example

/rec/inspire-om-design-patterns/pointTimeSeriesObservation	When the Observation represents a time-series of point measurements of a property at a fixed location in space the specialised observation ‘PointTimeSeriesObservation’ SHOULD be used

Point TimeSeries Observation class diagram is introduced in the figure below.
“Table 2 : Point TimeSeries Observation – example content description” right after provides a description on how each information element is to be provided.

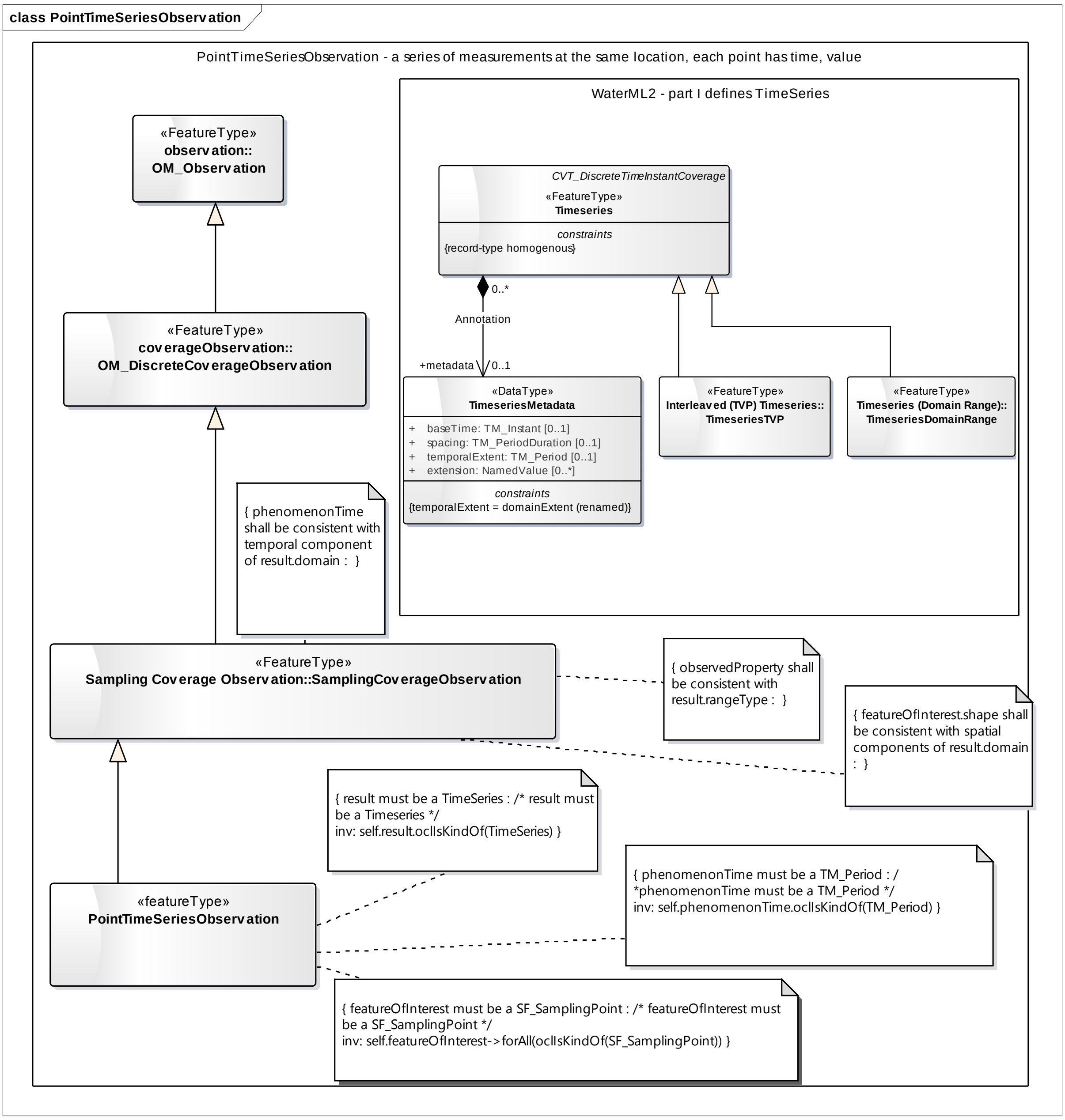


Figure 7 : Point TimeSeries Observation – class diagram

Two types of Timeseries are identified in WaterML2 – part I : Measurement Timeseries and Categorical Timeseries. An example of the concrete type 'wml2:MeasurementTimeseries' is provided in **"Annex B : INSPIRE specialised observations" chapter B.2 "Feature catalogue –** Specialised Observations. Extension (informative)

NOTE: Specimen Observation is not explicitly stated as a spatial object type in COMMISSION REGULATION (EU) 1253/2013 implementing Directive 2007/2/EC as regards interoperability of spatial data sets and services. . The need for including it was expressed by Member State experts through the temporary MIG sub-group on SOS and O&M (MIWP-7a). They are therefore to be considered informative.

Feature catalogue metadata

Application Schema	INSPIRE Application Schema Specialised Observations. Extension
Version number	1.0

Types defined in the feature catalogue

Type	Package	Stereotypes
SpecimenObservation	Specimen Observations	«featureType»
SpecimenTimeSeriesObservation	Specimen Observations	«featureType»

A.1.1.1 SpecimenObservation

SpecimenObservation

Name:	Specimen Observation
Subtype of:	SamplingCoverageObservation
Definition:	Observation that represents a measurement of a property of a Specimen at a single point in time.
Description:	The SpecimenObservation represents a single measurement or estimation of a property of a Specimen at a single point in time. For example the Nitrate concentration of a water sample taken from a lake.
Stereotypes:	«featureType»

Constraint: featureOfInterest must be a SF_Specimen

Natural language:	featureOfInterest must be a SF_Specimen
OCL:	inv: self.featureOfInterest->forAll(oclIsKindOf(SF_Specimen))

Constraint: SF_Specimen samplingLocation is mandatory

Natural language:	SF_Specimen samplingLocation is mandatory
OCL:	inv: featureOfInterest.SF_Specimen.samplingLocation -> notEmpty()

Constraint: phenomenonTime must be a TM_Instant

Natural language:	phenomenonTime must be a TM_Instant
OCL:	inv: self.phenomenonTime.oclIsKindOf(TM_Instant)

Constraint: result must be a CV_DiscretePointCoverage

Natural language:	result must be a CV_DiscretePointCoverage
OCL:	inv: self.result.oclIsKindOf(CV_DiscretePointCoverage)

A.1.1.2 SpecimenTimeSeriesObservation

SpecimenTimeSeriesObservation

Name:	SpecimenTimeSeriesObservation
Subtype of:	SamplingCoverageObservation
Definition:	Observation that represents a time-series of point measurement of a property of a Specimen analysed at regular intervals
Description:	The SpecimenTimeSeriesObservation represents a time series of observations on a Specimen made repeatedly with the same procedure.
Stereotypes:	«featureType»

Constraint: featureOfInterest must be a SF_Specimen

Natural language:	featureOfInterest must be a SF_Specimen
OCL:	inv: self.featureOfInterest->forAll(oclIsKindOf(SF_Specimen))

Constraint: SF_Specimen samplingLocation is mandatory

Natural language:	SF_Specimen samplingLocation is mandatory
OCL:	inv: featureOfInterest.SF_Specimen.samplingLocation -> notEmpty()

Constraint: phenomenonTime must be a TM_Period

SpecimenTimeSeriesObservation	
Natural language:	phenomenonTime must be a TM_Period
OCL:	inv: self.phenomenonTime.oclIsKindOf(TM_Period)

Constraint: result must be a TimeSeries

Natural language:	result must be a Timeseries
OCL:	inv: self.result.oclIsKindOf(TimeSeries)

wml2: MeasurementTimeseries implementation**”.**

O&M Attribute/association	Example content description
processUsed	Process instance providing information about the responsible party, documented process etc. *See chapter 7.1.4 Procedure.*
featureOfInterest	A *SF_SamplingPoint* at the geographic location of the measurement. It must be the same location for the entire time series. Note that in the case of fixed monitoring stations further guidance are provided at chapter 7.1.6 Linking to monitoring facility / network.
phenomenonTime	A time period (in ISO 8601) representing the start and end date/times of the time series. *See chapter 7.1.1 Observation.*
observedProperty	Link to a vocabulary defining ozone hourly mean. *See chapter 7.1.2 Observed property.*
result	The result should be a set of TimeValuePairs encoded according to *Annex B: INSPIRE specialised observations.* It should also indicate the units used in the result (ex : µg/m³ or ppm).
resultTime	The time the result was made available (e.g. published). *See chapter 7.1.1 Observation.*

Table 2 : Point TimeSeries Observation – example content description

6.2.2.3. MultiPoint Observation

An example of such case could be a distributed sensor network reporting the temperature at different locations for the same time.
The points themselves are not on a grid but may be distributed in any manner – for example unevenly spaced around a coastline
The featureOfInterest represents a bounding box or polygon that includes all the measurement locations

The ‘MultiPointObservation’ specialised observation provides the necessary artifact to exchange such information.

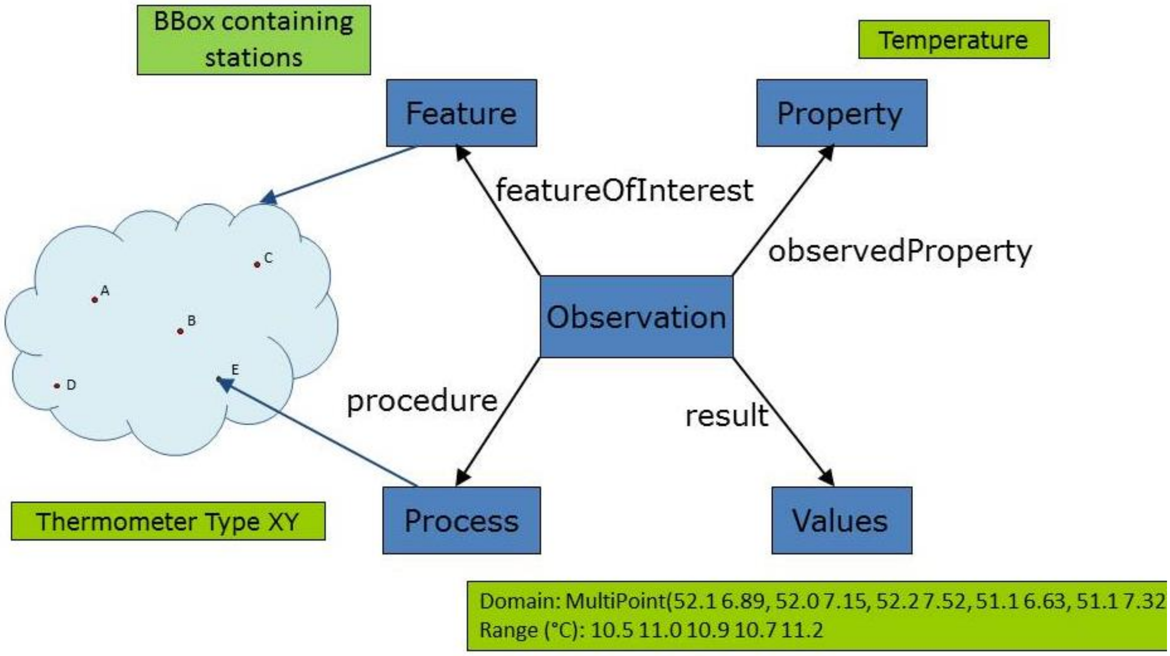


Figure 8 : MultiPoint Observation – schematic example

/rec/inspire-om-design-patterns/multiPointObservation	When the Observation represents a set of measurements on the same observed property all made at exactly the same time but at different locations the specialised observation 'MultiPointObservation' SHOULD be used

MultiPoint Observation class diagram is introduced in the figure below.
"Table 3 : MultiPoint Observation – example content description" right after provides a description on how each information element is to be provided.

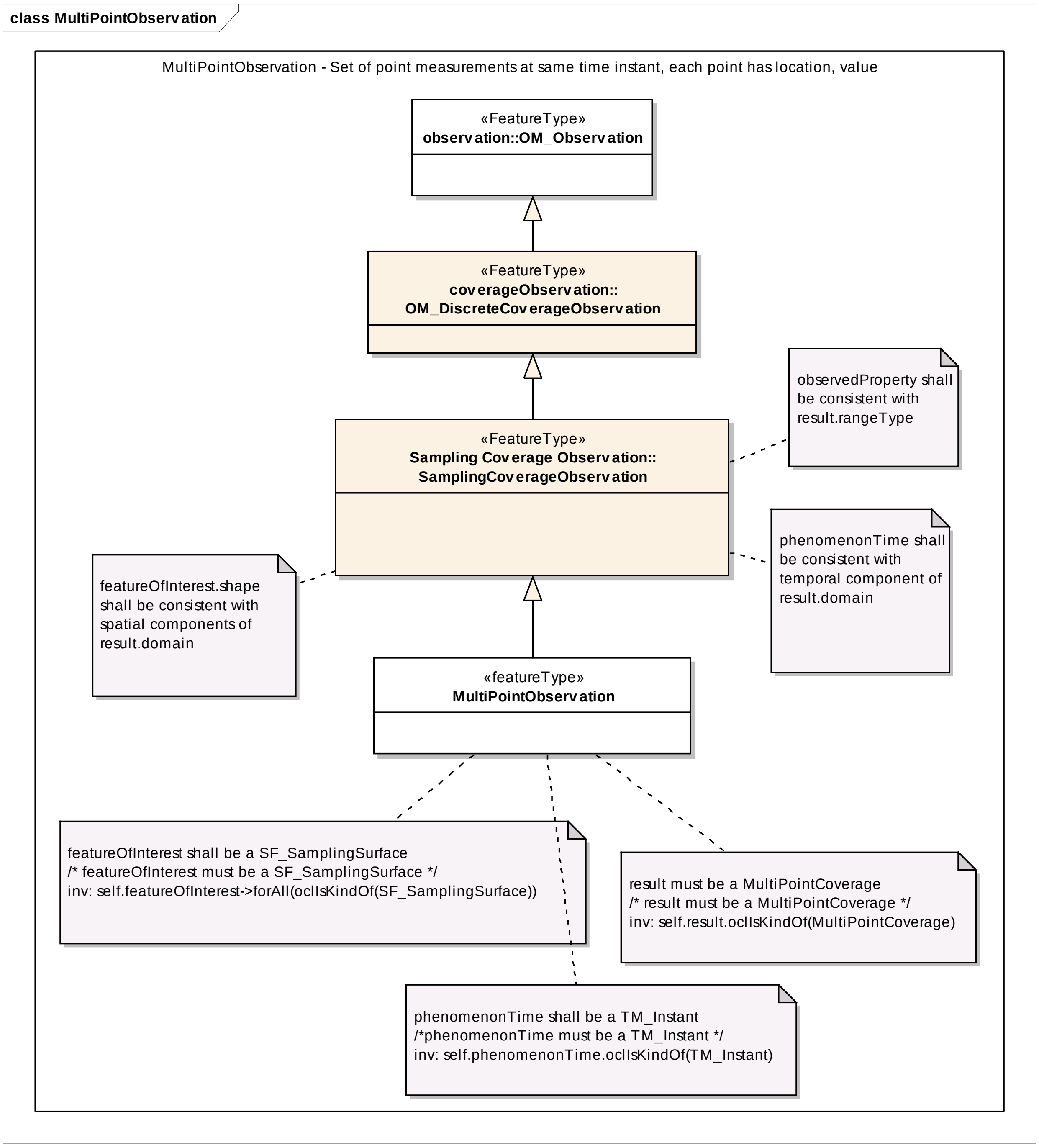


Figure 9 : MultiPoint Observation – class diagram

Note that MultiPoint contains multiple single gml:Point as members.

O&M Attribute/association	Example content description
processUsed	Process instance providing information about the responsible party, documented process etc. *See chapter 7.1.4 Procedure.*
featureOfInterest	A SF_SamplingSurface with a geometry that defines the total extent of the MultiPointObservation. (i.e. a bounding box or polygon that includes all the measurement locations).
phenomenonTime	A time instant (in ISO 8601) when the observations were taken (all measurements must be taken at the same time instant). *See chapter 7.1.1 Observation.*

observedProperty	Link to a vocabulary defining temperature. *See chapter 7.1.2 Observed property.*
result	The result should be a GML MultiPointCoverage. For large result sets an out-of-band result (e.g. in binary) may be provided.
resultTime	The time the result was made available (e.g. published). *See chapter 7.1.1 Observation.*

Table 3 : MultiPoint Observation – example content description

6.2.3 Trajectory based Observations

6.2.3.1. Profile Observation

An example of such case could be a ship measuring the salinity at varying depths along a water column, the featureOfInterest being a vertical water column at one given ship location.
The actual locations of individual measurements along the water column are provided with the result. All measurements are located within the water column with either relative position (from start of water column) or absolute position (i.e. coordinates including the depth).

The 'ProfileObservation' specialised observation provides the necessary artifact to exchange such information.

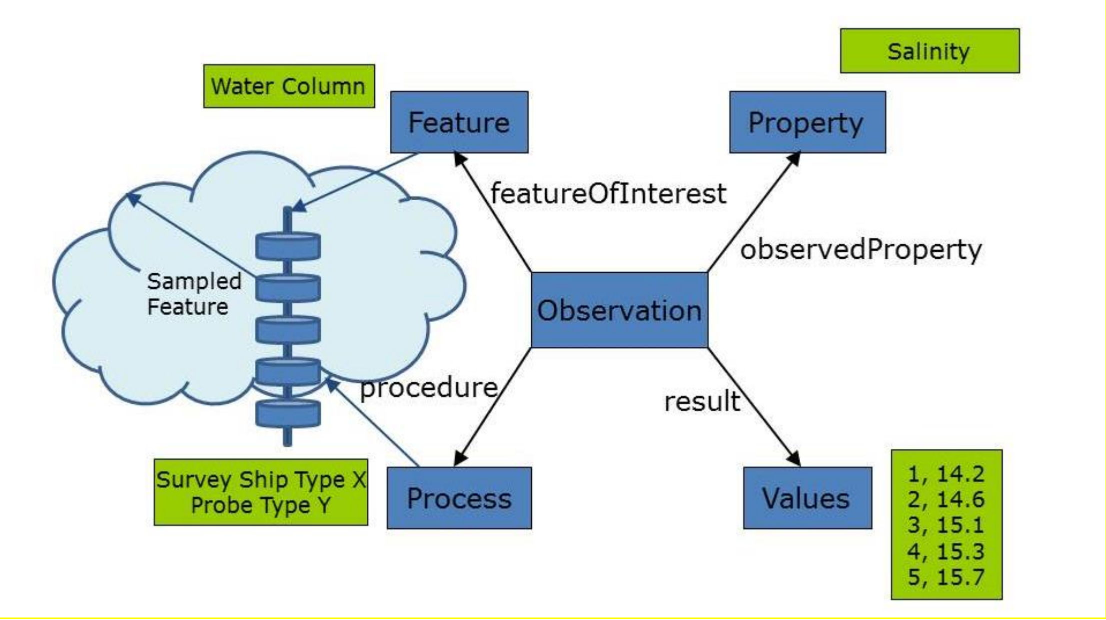


Figure 10 : Profile Observation – schematic example

/rec/inspire-om-design-patterns/profileObservation	When the Observation represents the measurement of a property along a vertical profile in space at a single time instant the specialised observation 'ProfileObservation' SHOULD be used

Profile Observation class diagram is introduced in the figure below.
"Table 4 : Profile Observation – example content description" right after provides a description on how each information element is to be provided.

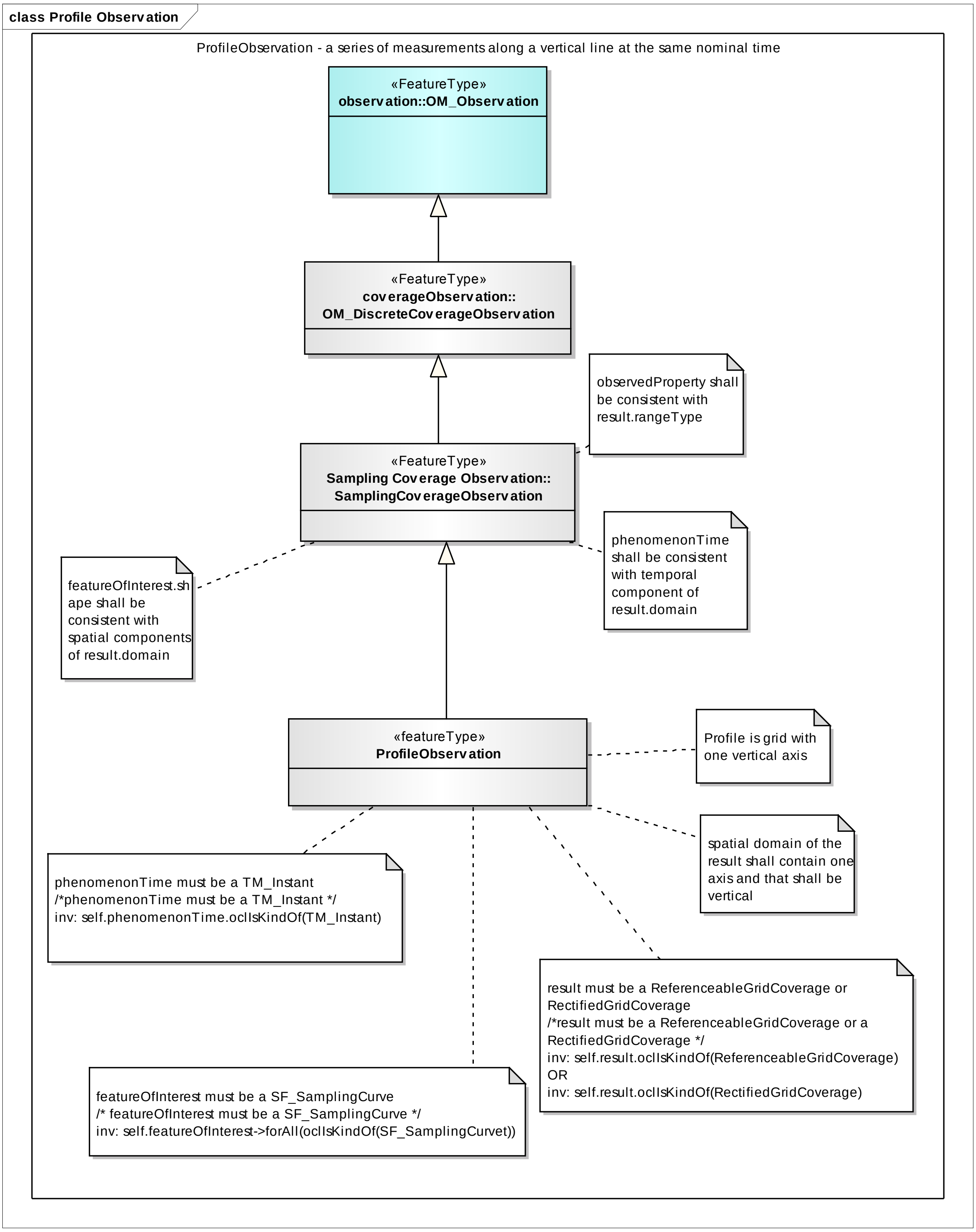


Figure 11 : Profile Observation – class diagram

O&M Attribute/association	Example content description
processUsed	Process instance providing information about the responsible party, documented process etc. *See chapter 7.1.4 Procedure.*
featureOfInterest	A *SF_SamplingCurve* with a geometry that defines the geometry of the profile.
phenomenonTime	A time instant (in ISO 8601) when the observations were taken. *See chapter 7.1.1 Observation.*
observedProperty	Link to a vocabulary defining salinity. *See chapter 7.1.2 Observed property.*
result	The result encoded according to *Annex B: INSPIRE specialised observations.* It should also indicate the units used in the result. For large result sets an out-of-band result (e.g. in binary) may be provided.
resultTime	The time the result was made available (e.g. published). *See chapter 7.1.1 Observation.*

Table 4 : Profile Observation – example content description

6.2.3.2. Trajectory Observation

An example of such case could be a moving ship making sea surface temperature measurements, the featureOfInterest being the trajectory of the ship

The actual locations of individual measurements along the trajectory are provided with the results.
All measurements are located within the trajectory with either relative position (from start of the trajectory) or absolute position (i.e. coordinates).
Each measurement is made at a separate point along the trajectory and at a separate time. The result is therefore a set of time, location, value triples.

The 'TrajectoryObservation' specialised observation provides the necessary artifact to exchange such information.

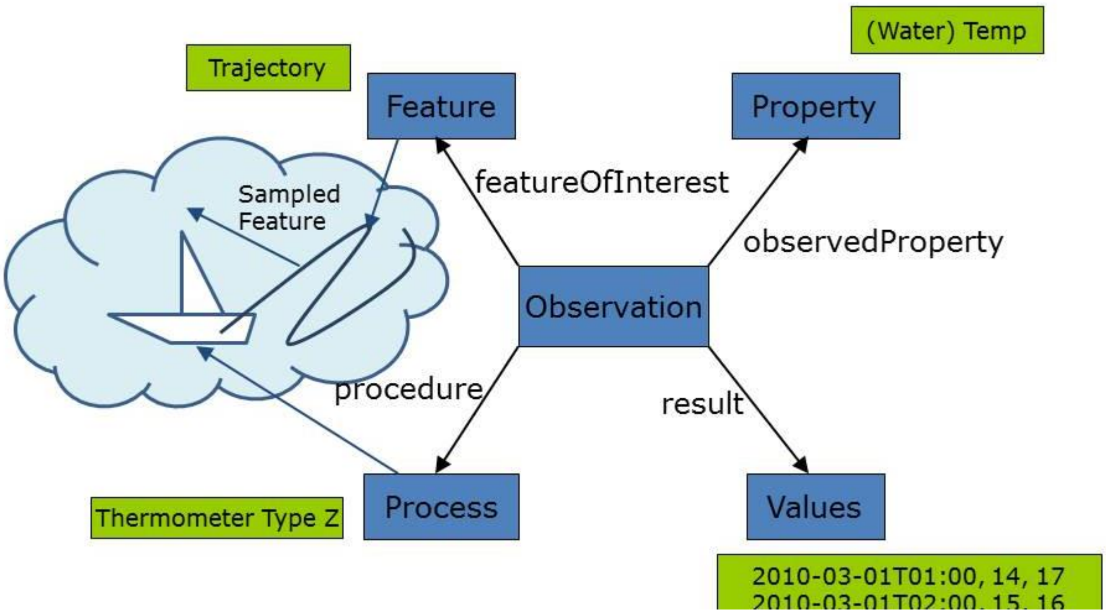


Figure 12 : Trajectory Observation – schematic example

/rec/inspire-om-design-patterns/trajectoryObservation	When the Observation represents the measurement of a property along a meandering curve in time and space the specialised observation 'TrajectoryObservation' SHOULD be used

Trajectory Observation class diagram is introduced in the figure below.
“Table 5 : Trajectory Observation – example content description” right after provides a description on how each information element is to be provided.

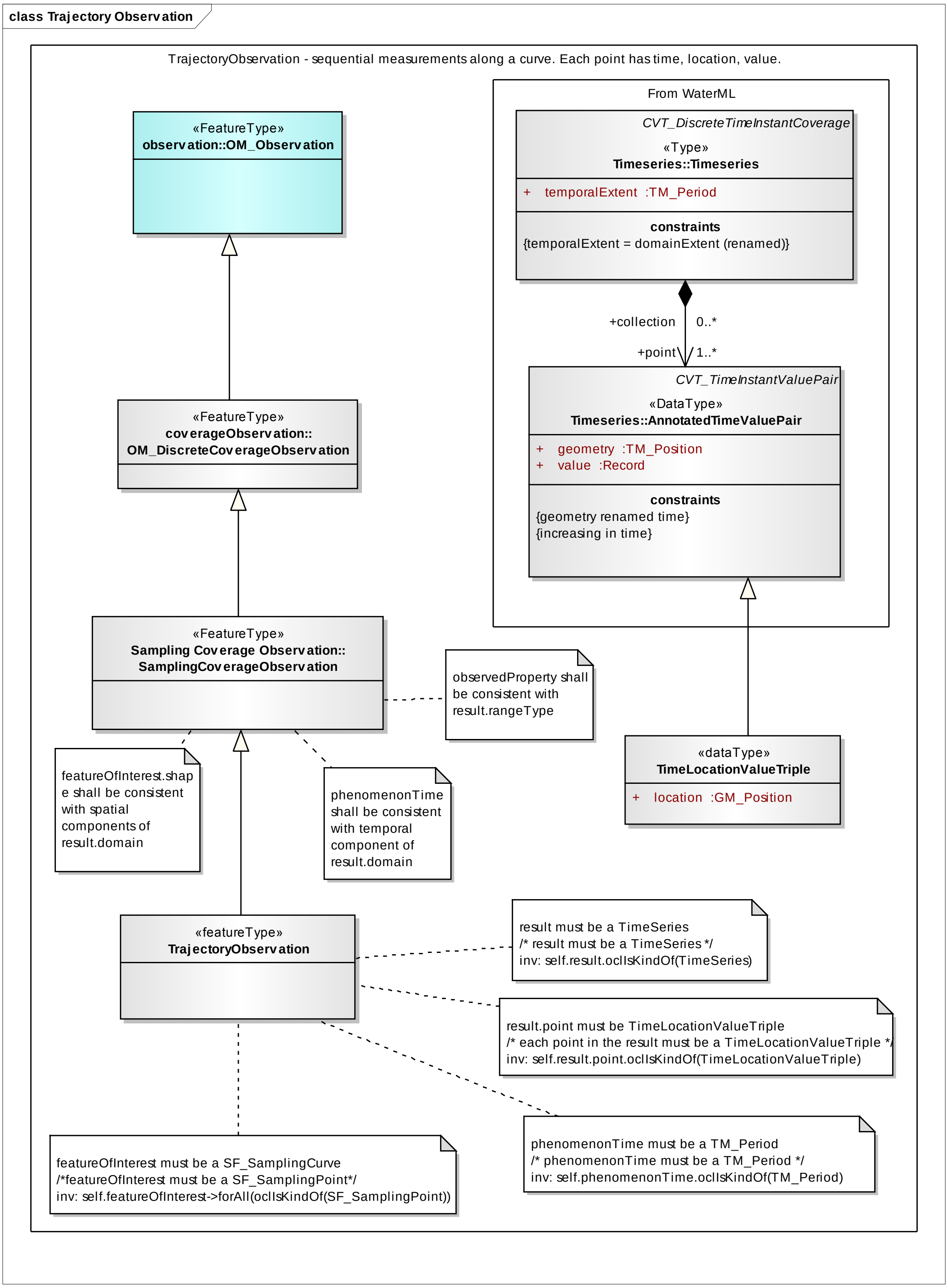


Figure 13 : Trajectory Observation – class diagram

O&M Attribute/association	Example content description
processUsed	Process instance providing information about the responsible party, documented process etc. *See chapter 7.1.4 Procedure.*
featureOfInterest	A *SF_SamplingCurve* with a geometry that defines the geometry of the trajectory.
phenomenonTime	A time period (in ISO 8601) representing the start and end date/times of the trajectory. *See chapter 7.1.1 Observation.*
observedProperty	Link to a vocabulary defining water temperature. *See chapter 7.1.2 Observed property.*
result	The result (a set of Location, Time, Value triples) encoded according to *Annex B: INSPIRE specialised observations.* It should also indicate the units used in the result.
resultTime	The time the result was made available (e.g. published). *See chapter 7.1.1 Observation.*

Table 5 : Trajectory Observation – example content description

6.2.4 Grid based Observations

6.2.4.1. Grid Observation

An example of such case could be the determination of the ocean color over a gridded field taken at a single instant in time such as a rectified or georeferenced satellite data.
The featureOfInterest represents the extent of the grid.
The actual locations of individual observations within the grid are provided with the results. All individual measurement locations are located within the grid boundaries. The grid cell being observed is provided in the domain of the coverage result, the color observed is provided within the range of the coverage result

The 'GridObservation' specialised observation provides the necessary artifact to exchange such information.

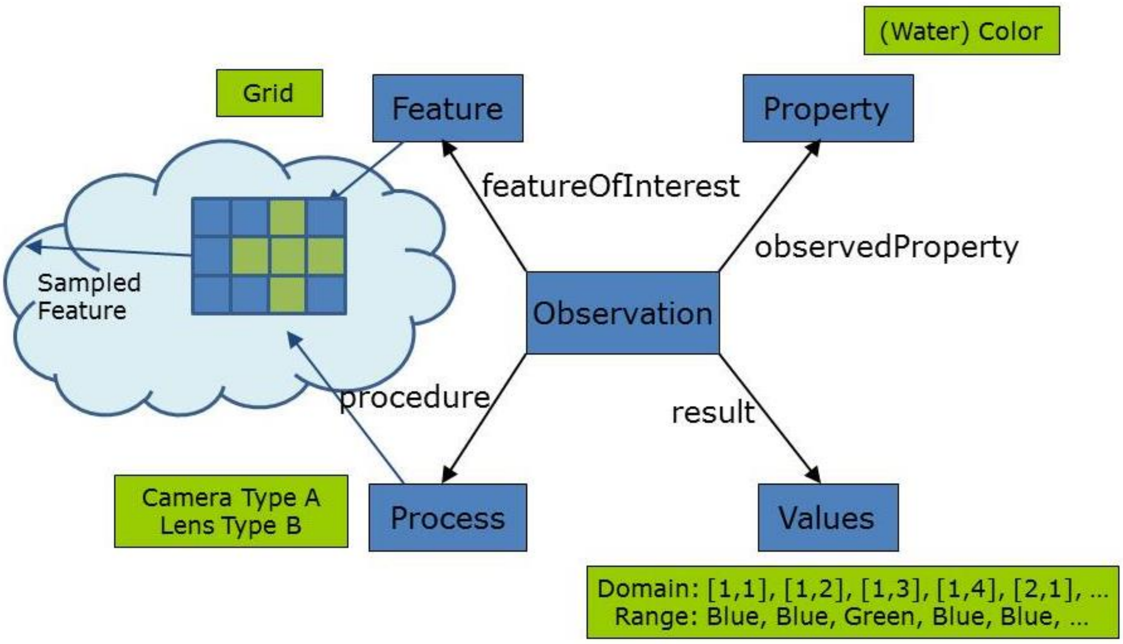


Figure 14 : Grid Observation – schematic example

/rec/inspire-om-design-patterns/gridObservation	When the Observation represents a gridded field at a single time instant the specialised observation 'GridObservation' SHOULD be used

Grid Observation class diagram is introduced in the figure below.
"Table 6 : Grid Observation – example content description" right after provides a description on how each information element is to be provided.

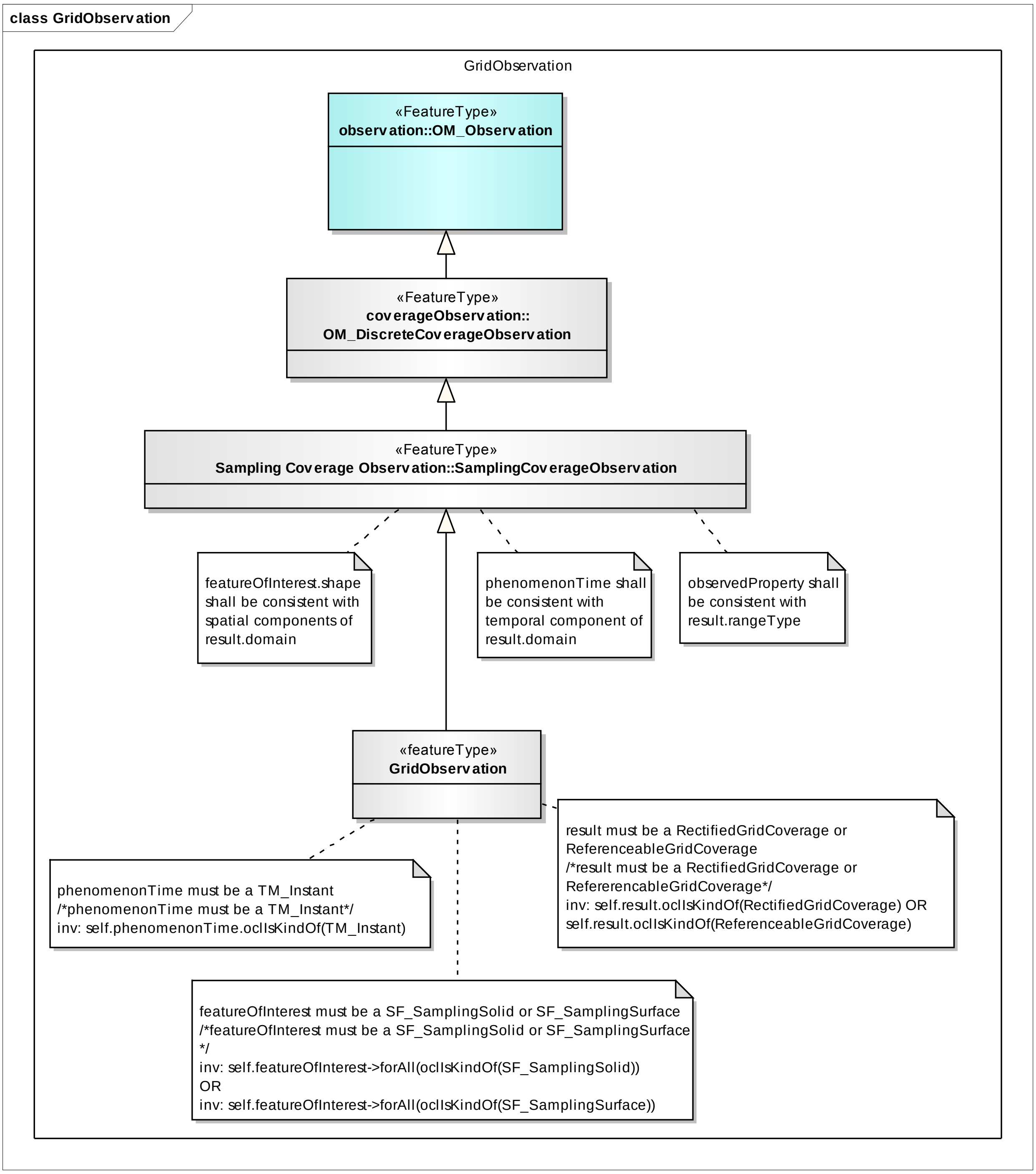


Figure 15 : Grid Observation – class diagram

O&M Attribute/association	Example content description

processUsed	Process instance providing information about the responsible party, documented process etc. *See chapter 7.1.4 Procedure.*
featureOfInterest	A *SF_SamplingSurface* that defines the extent of the Grid of data.
phenomenonTime	A time instant e.g. 2012-01-30T10:30:00.00Z (in ISO 8601 including time zone) which the Grid represents. *See chapter 7.1.1 Observation.*
observedProperty	Link to a vocabulary defining water color. *See chapter 7.1.2 Observed property.*
result	The result containing the grid points (as the domain of the coverage) and the observed ocean colour values (as the rangeSet of the coverage encoded according to *Annex B: INSPIRE specialised observations.* For large grids an out-of-band result (e.g. in binary) may be provided.
resultTime	The time the result was made available (e.g. published). *See chapter 7.1.1 Observation.*

Table 6 : Grid Observation – example content description

6.2.4.2. GridSeries Observation

An example of such case could be the determination of the ocean temperature over a gridded field studied over time such as in a simulation/model run
The featureOfInterest represents the extent of the grid. The ocean temperature is modelled for each grid cell over time.
The actual locations of individual observations within the grid are provided with the results. All measurement locations are located within the grid boundaries.

The 'GridSeriesObservation' specialised observation provides the necessary artifact to exchange such information.

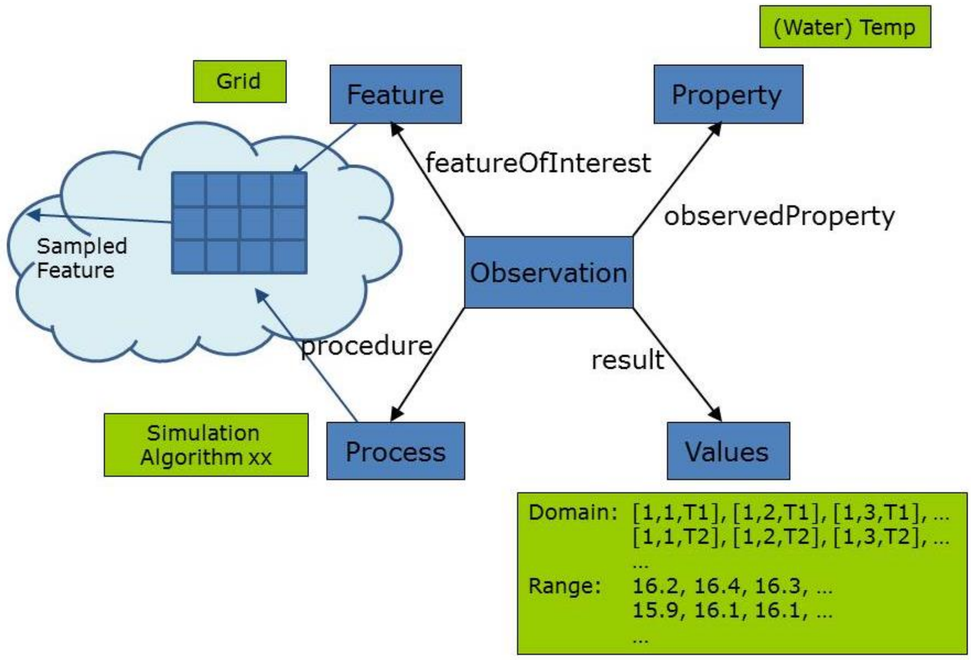


Figure 16 : GridSeries Observation – schematic example

/rec/inspire-om-design-patterns/gridSeriesObservation	When the Observation represents an evolving gridded field at a succession of time the specialised observation 'GridSeriesObservation' SHOULD be used

GridSeries Observation class diagram is introduced in the figure below.
"Table 7 : GridSeries Observation – example content description" right after provides a description on how each information element is to be provided.

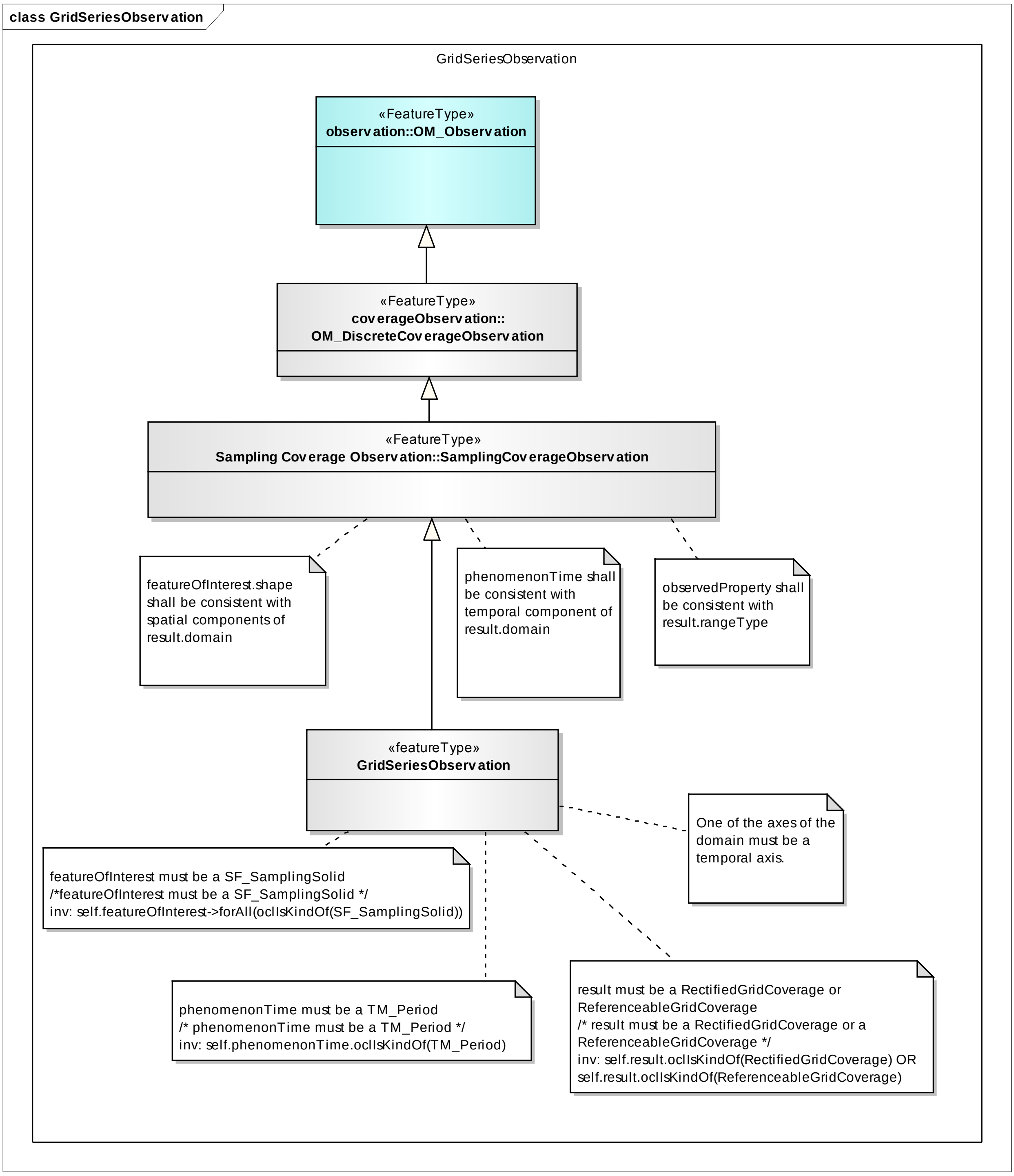


Figure 17 : GridSeries Observation – class diagram

O&M Attribute/association	Example content description
processUsed	Process instance providing information about the responsible party, documented process etc. *See chapter 7.1.4 Procedure.*
featureOfInterest	A *SF_SamplingSurface* that defines the extent of the Grid of data.
phenomenonTime	A time period (in ISO 8601) representing the start and end date/times of the model run. *See chapter 7.1.1 Observation.*
observedProperty	Link to a vocabulary defining water temperature. *See chapter 7.1.2 Observed property.*
result	The result containing the grid points (as the spatio-temporal domain of the coverage with one of the axes being be a temporal axis) and the observed sea surface temperature values (as the rangeSet of the coverage encoded according to *Annex B: INSPIRE specialised observations.* It should also indicate the units used in the result. For large grids an out-of-band result (e.g. in binary) may be provided.
resultTime	The time the result was made available (e.g. published). *See chapter 7.1.1 Observation.*

Table 7 : GridSeries Observation – example content description

6.2.5 Specimen based Observations

6.2.5.1. Specimen Observation

An example of such case would be a sample or specimen taken from the sampled feature and analysed once *ex situ* in an external laboratory.

The 'SpecimenObservation' specialised observation provides the necessary artifact to exchange such information.

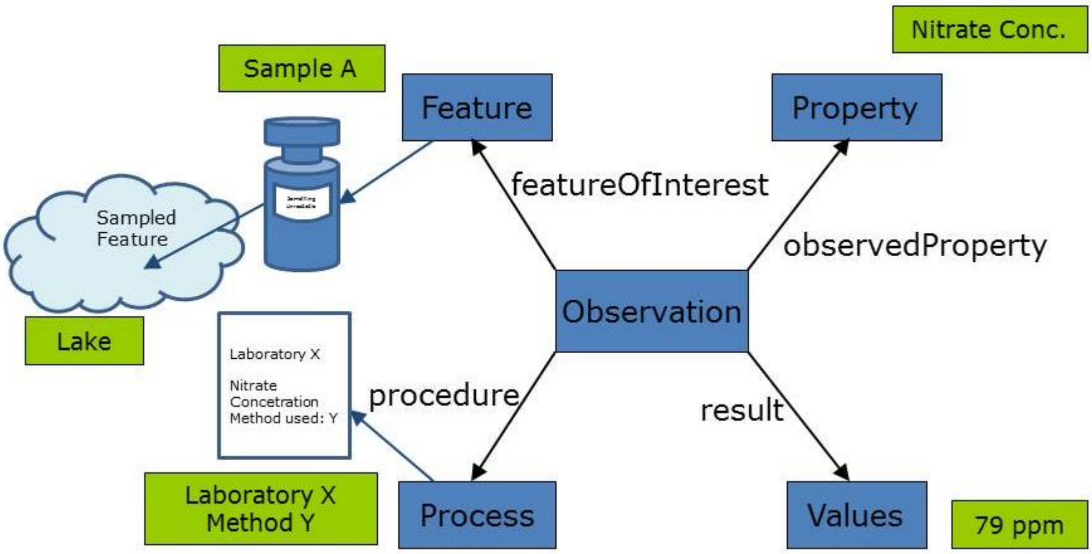


Figure 18 : Specimen Observation – schematic example

/rec/inspire-om-design-patterns/specimenObservation	When the Observation represents a measurement of a property of a Specimen at a single point in time the specialised observation 'SpecimenObservation' SHOULD be used.

Specimen Observation class diagram is introduced in the figure below.

"Table 8 : Specimen Observation – example content description" provides a description on how each information element should be provided.

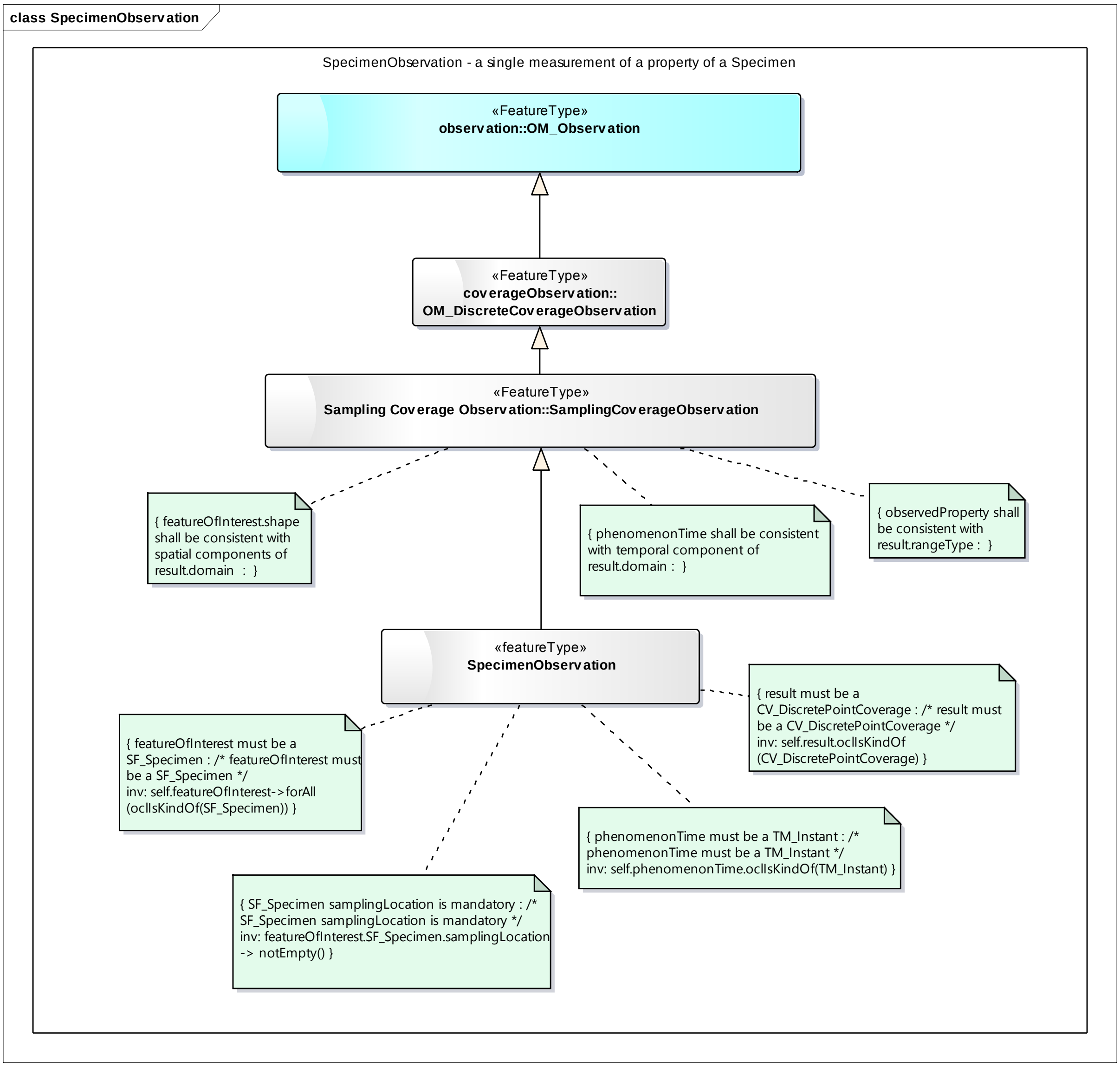


Figure 19: Specimen Observation – class diagram

O&M OM_Observation Attribute/association	Example content description
processUsed	Process instance providing information about the responsible party, documented process etc. *See chapter 7.1.4 Procedure.*
featureOfInterest	A *SF_Specimen* corresponding to the water bottle the concentration is measured from.
phenomenonTime	A time instant e.g. 2012-01-30T10:30:00.00Z (in ISO 8601). *See chapter 7.1.1 Observation.*
observedProperty	Link to a vocabulary defining water temperature. *See chapter 7.1.2 Observed property.*
result	Single valued coverage recording an estimate of the observed property (e.g. 79) and the unit used in the result (e.g ppm).
resultTime	The time the result was made available (e.g. published). *See chapter 7.1.1 Observation.*

O&M SF_Specimen Attribute/association	Example content description
materialClass	Basic classification of the material type of the specimen (here : water)
samplingTime	A time instant (in ISO 8601) representing the moment when the specimen was retrieved from the sampled feature.
samplingMethod	Information about the sampling context: method used, the responsible party, etc…
sampledFeature	Link to the domainFeature being sampled (ex : the lake of code 'xxxx')

Table 8 : Specimen Observation – example content description

NOTE: Specimen Observation is not explicitly stated as a spatial object type in COMMISSION REGULATION (EU) 1253/2013 implementing Directive 2007/2/EC as regards interoperability of spatial data sets and services. . The need for including it was expressed by Member State experts through the temporary MIG sub-group on SOS and O&M (MIWP-7a). Section 6.2.5.1 is therefore to be considered informative.

6.2.5.2. Specimen TimeSeries Observation

An example of such case would be a sample or specimen taken from the sampled feature and re-analysed at regular intervals *ex situ* in an external laboratory. This could apply to the measurement of the biochemical oxygen demand (BOD) in waste water treatment plants; it is measured by taking one sample and studying BOD evolution over time in a laboratory. While the usual result requested is BOD 5 (5 difference of O_2 consumption by micro-organisms after 5 days) or BOD 21, in some cases you may require the entire time series.

The 'SpecimenTimeSeriesObservation' specialised observation provides the necessary artifact to exchange such information.

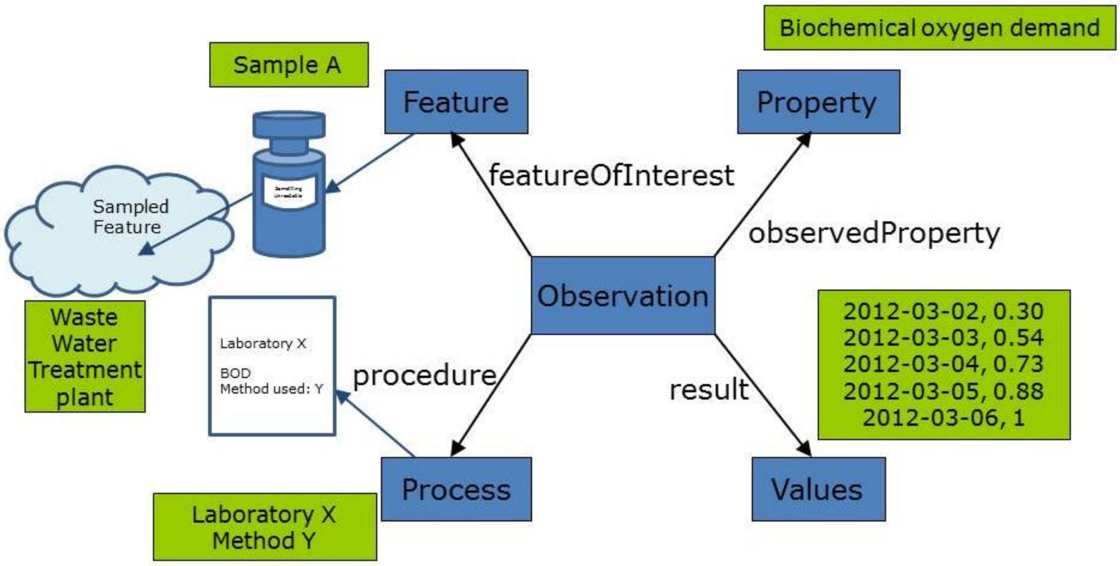


Figure 20 : Specimen TimeSeries Observation – schematic example

/rec/inspire-om-design-patterns/specimenTimeSeriesObservation	When the Observation represents a measurement of a property of a Specimen analysed at regular intervals the specialised observation 'SpecimenTimeSeriesObservation' SHOULD be used

Specimen TimeSeries Observation class diagram is introduced in the figure below.

“Table 9 : Specimen TimeSeries Observation – example content description” right after provides a description on how each information element is to be provided.

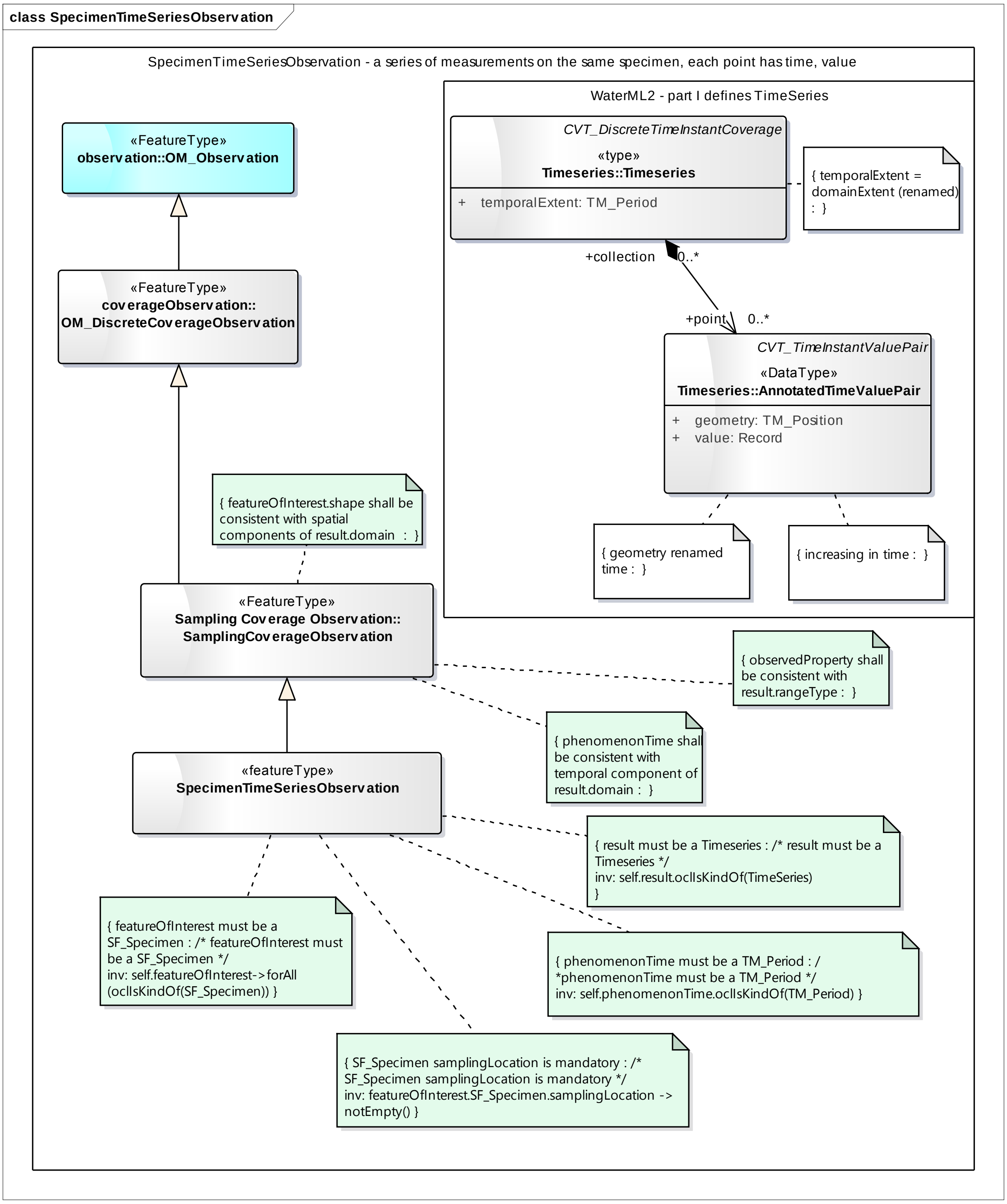


Figure 21 : Specimen TimeSeries Observation – class diagram

O&M OM_Observation Attribute/association	Example content description
processUsed	Process instance providing information about the responsible party, documented process etc. *See chapter 7.1.4 Procedure.*
featureOfInterest	A *SF_Specimen* corresponding to the water bottle the reapeated measurement are taken from.
phenomenonTime	A time period (in ISO 8601) representing the start and end date/times of the time series. *See chapter 7.1.1 Observation.*
observedProperty	Link to a vocabulary defining biochemical oxygen demand. *See chapter 7.1.2 Observed property.*
result	The result should be a set of TimeValuePairs encoded according to *Annex B: INSPIRE specialised observations*. It should also indicate the units used in the result.
resultTime	The time the result was made available (e.g. published). *See chapter 7.1.1 Observation.*

O&M SF_Specimen Attribute/association	Example content description
materialClass	Basic classification of the material type of the specimen (here : water)
samplingTime	A time instant (in ISO 8601) representing the moment when the specimen was retrieved from the sampled feature.
samplingMethod	Information about the sampling context: method used, the responsible party, etc…
sampledFeature	Link to the domainFeature being sampled (ex : the waste water treatment plant of code 'xxxx')

Table 9 : Specimen TimeSeries Observation – example content description

NOTE: Specimen TimeSeries Observation is not explicitly stated as a spatial object type in COMMISSION REGULATION (EU) 1253/2013 implementing Directive 2007/2/EC as regards interoperability of spatial data sets and services. The need for including it was expressed by Member State experts through the temporary MIG sub-group on SOS and O&M (MIWP-7a). Section 6.2.5.2 is therefore to be considered informative.

7 O&M INSPIRE profile

Requirements for the structure and content of XML data instances provided by web services or servers.

Requirements class	**/req/inspire-om-core**
Target type	XML data document
Name	INSPIRE profile for the implementation of O&M
Dependency	/req/inspire-observation-model
Dependency	http://www.opengis.net/spec/OMXML/2.0/req/observation
Dependency	http://www.opengis.net/spec/OMXML/2.0/req/sampling
Dependency	http://www.opengis.net/spec/OMXML/2.0/req/spatialSampling
Recommendation	/rec/inspire-om-core/observation-identifier
Recommendation	/rec/inspire-om-core/observation-time
Recommendation	/rec/inspire-om-core/observedProperty-communityVocabulary
Recommendation	/rec/inspire-om-core/observedProperty-skos
Recommendation	/rec/inspire-om-core/featureOfInterest-type
Recommendation	/rec/inspire-om-core/featureOfInterest-identifier
Recommendation	/rec/inspire-om-core/featureOfInterest-sampledFeature
Recommendation	/rec/inspire-om-core/featureOfInterest-sampledFeatureIdentifier
Recommendation	/rec/inspire-om-core/featureOfInterest-depth-elevation
Recommendation	/rec/inspire-om-core/procedure-noSensorInstance
Recommendation	/rec/inspire-om-core/procedure-communityVocabulary
Recommendation	/rec/inspire-om-core/procedure-process
Recommendation	/rec/inspire-om-core/procedure-identifier
Requirement	/req/inspire-om-core/procedure-processParameter
Recommendation	/rec/inspire-om-core/procedure-processParameterSch
Recommendation	/rec/inspire-om-core/onlineResource
Requirement	/req/inspire-om-core/relatedMonitoringFeature-parameter
Recommendation	/rec/inspire-om-core/relatedMonitoringFeature-URI
Recommendation	/rec/inspire-om-core/observationSet

7.1 Core Observation profile

7.1.1 Observation

/rec/inspire-om-core/observation-identifier	A om:OM_Observation SHOULD include a gml:identifier element and its value SHOULD be a unique and persistent HTTP URI as specified by the appropriate naming authority.

/rec/inspire-om-core/observation-time	The values of temporal elements - om:phenomenonTime, om:validTime and om:resultTime - SHOULD be encoded using the ISO8601 extended time format and SHOULD include the time offset from UTC.

7.1.2 Observed property

/rec/inspire-om-core/observedProperty-communityVocabulary	The observedProperty SHOULD be a reference to a community managed vocabulary: - The value of the om:observedProperty/@xlink:href SHOULD be an HTTP URI through which the observedProperty description can be downloaded - The value of the om:observedProperty/@xlink:title attribute SHOULD carry the name of the observed property

/rec/inspire-om-core/observedProperty-skos	In case a RDF/XML description is used: - The value of the om:observedProperty/@xlink:href attribute SHOULD be an HTTP URI that dereferences to a RDF/XML description of the property type that conforms to the community defined skos concepts - The value of the om:observedProperty/@xlink:title attribute SHOULD match the value of the associated skos:Concept/skos:prefLabel.

Note: *INSPIRE has developed an ObservableProperty model to provide a framework for extending a pre-defined term in a vocabulary with additional information, such as constraints (e.g. the earlier wavelength example), or statistical measures (e.g. the earlier temperature example).*
It is non normative and provided for information in Annex J: Observable properties model.

7.1.3 FeatureOfInterest

7.1.3.1. FeatureOfInterest type

In some cases, the featureOfInterest exists only because an observation exists, i.e. it is only defined in order to perform an observation of the real world; in this case, a specific sampling feature must be defined to serve as featureOfInterest. In other cases, a feature used in other contexts within the domain will also serve as a featureOfInterest for an observation.

This situation is summarized in Figure 22 below.

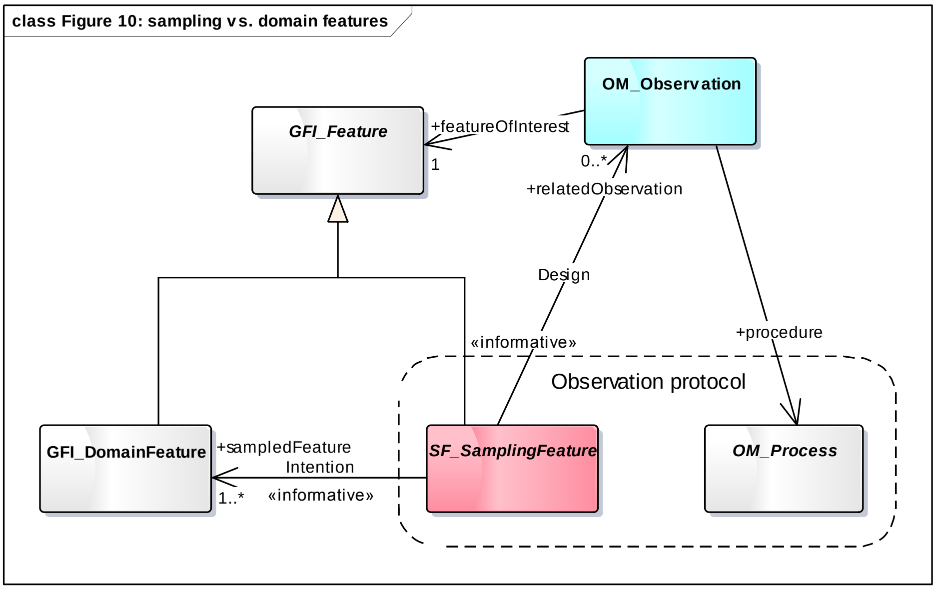


Figure 22 : Relationship between sampling and domain features [ISO 19156:2011, Figure 10]

/rec/inspire-om-core/featureOfInterest-type	Unless otherwise specified in a given observation subtype, the featureOfInterest SHOULD be one of SF_SamplingFeature derived Types.

/rec/inspire-om-core/featureOfInterest-identifier	The featureOfInterest of an om:Observation SHOULD be provided with its gml:identifier.

7.1.3.2. sampledFeature

In many cases, only a featureOfInterest is provided in the form of a samplingFeature; the description of the associated sampledFeature is often missing. SampledFeature information referring to the media or realm covered is useful for providing a better understanding of the context of the featureOfInterest

/rec/inspire-om-core/featureOfInterest-sampledFeature	When using a SF_SamplingFeature as featureOfInterest, at least one domain feature (GFI_Feature) SHOULD be provided as sampledFeature to provide the necessary context. In case such feature is not available, then a URI entry to a reference ontology (e.g. NASA's SWEET Ontology[2]) SHOULD be provided.

[2] *http://sweet.jpl.nasa.gov/*

```
The following example points to a URI which, when dereferenced, provides
the corresponding sampled domain feature (here an aquifer)
<sf:sampledFeature xlink:href="http://ressource.brgm-
rec.fr/data/EntiteHydroGeol/113AA01" xlink:title="Calcaire Ludien de
l'Eocène sup. du Bassin Parisien"/>

In the same domain context, but without such data content available, one
could use:
<sf:sampledFeature
xlink:href="https://sweet.jpl.nasa.gov/2.3/realmHydro.owl#Aquifer"
xlink:title="Aquifer"/>
```

Figure 23 : Linking to sampledFeature

/rec/inspire-om-core/featureOfInterest-sampledFeatureIdentifier	When a domain feature (GFI_Feature) is provided as sampledFeature its gml:identifier SHOULD be provided

7.1.3.3. depth/elevation

/rec/inspire-om-core/featureOfInterest-depth-elevation	When using a SF_SamplingFeature as featureOfInterest, in order to indicate depth or elevation a 'sf:parameter' SHOULD be used. Its 'name' attribute SHOULD be 'depth' or 'elevation' (depending on the context) and 'value' attribute SHOULD be of type 'gml:MeasureType' with indication of the 'uom'.

7.1.4 Procedure

Within this profile, the observation procedure (OM_Process) is considered as an algorithm, sensor type, or time series type, but not as an individual, physical device (sensor instance). In INSPIRE context, the theme II.7 Environmental Monitorings Facilities provides the necessary elements to exchange such information (see INSPIRE *D2.8.III.7 INSPIRE Data Specification on Environmental Monitoring Facilities – Technical Guidelines).*

/rec/inspire-om-core/procedure-noSensorInstance	The OM_Process SHOULD NOT refer to the description of a sensor instance.

/rec/inspire-om-core/procedure-communityVocabulary	The procedure SHOULD be a reference to a community managed vocabulary exposed according to /rec/inspire-om-core/procedure/process.

The *Process* class defined within INSPIRE allows for the lightweight provision of procedural information. **The detailed *Process* feature catalogue is available in chapter "Annex C: INSPIRE Process" along with a standardised mapping to SensorML 1.0.1.**

/rec/inspire-om-core/procedure-process	Where the OM_Observation type or any sub-type thereof is used to make data available, either the Process Featuretype or its mapping to SensorML SHOULD be used to describe the procedure used in an OM_Observation

/rec/inspire-om-core/procedure-identifier	The procedure of an om:Observation SHOULD be provided with its gml:identifier

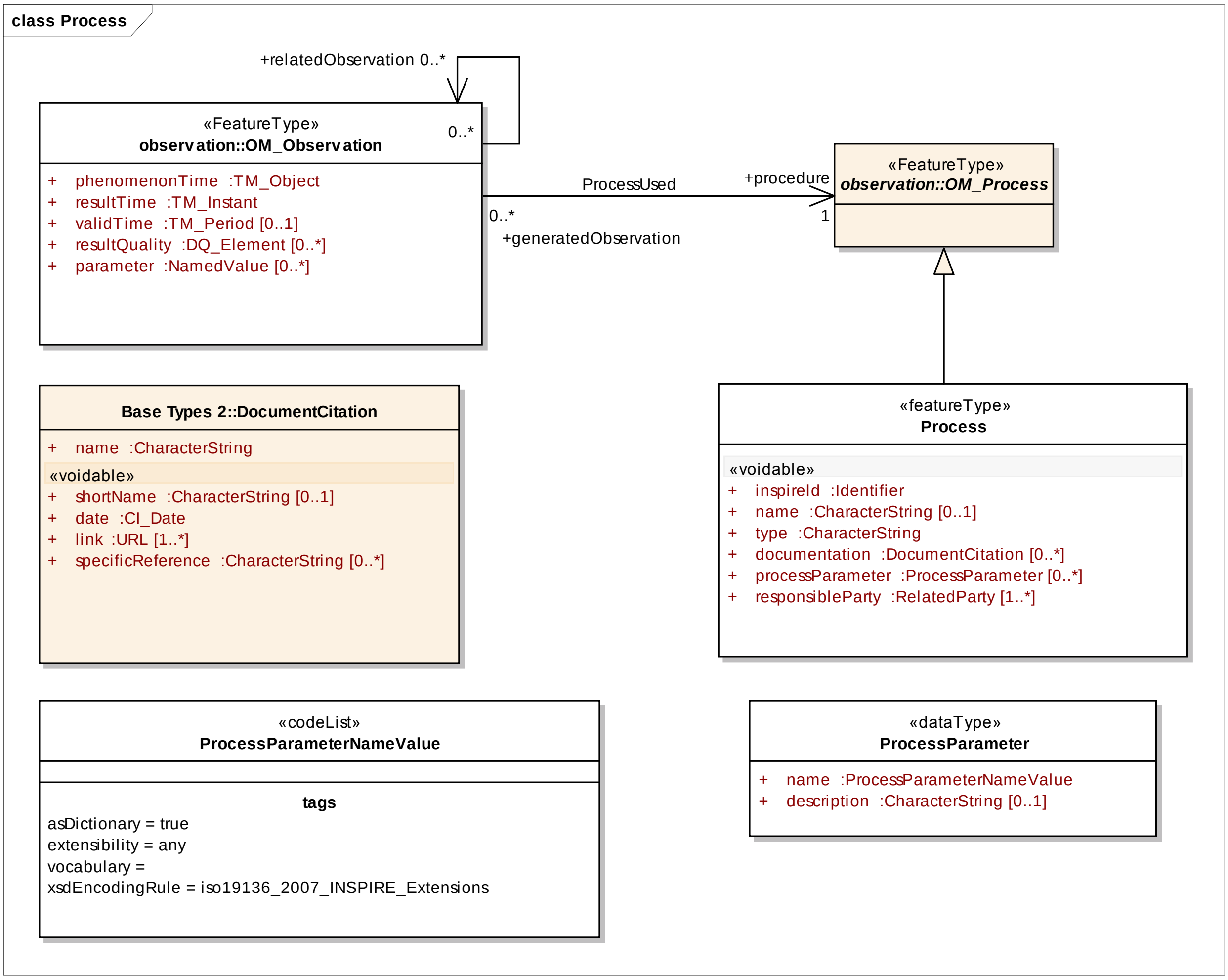


Figure 24 : Process Class

/req/inspire-om-core/procedure-processParameter	Where the OM_Observation type or any sub-type thereof is used to make data available and if the processParameter attribute is present in the procedure property of an OM_Observation object, its value (a name) SHALL be included in the parameter attribute of the OM_Observation object.

An example of such cross-reference is the following

```
Process
  • identifier: ukmo_global_model
  • documentation: http://www.metoffice.gov.uk/research/modelling-
    systems/unified-model/weather-forecasting
  • processParameter:
    http://inspire/processParameterValue.html#AnalysisTime
  • processParameter:
    http://inspire/processParameterValue.html#AssimilationWindow
OM_Observation
  • phenomenonTime: 00z 15/05/2011 - 00z 21/05/2011
  • resultTime: 0420z 15/05/2011
  • parameter: Name:
           http://inspire/processParameterValue.html#AnalysisTime
           Value: 00z 15/05/2011
```

```
•  parameter: Name:
          http://inspire/processParameterValue.html#AssimilationWindo
          w
          Value: 20z 14/05/2011 - 02z 15/05/2011
```

Figure 25 : processParameter cross reference example

/rec/inspire-om-core/procedure-processParameterSch	Where the processParameter attribute is used, schematron rules SHOULD be provided together with the schema in order to assure that all keys used in the observation parameters are also be listed under the process parameters.

7.1.5 Online resource

In cases where an observation is directly referenced using its identifier, the client is not aware of the actual service endpoint providing the response. The following recommendation helps solving that issue.

/rec/inspire-om-core/onlineResource	When providing a direct reference to an observation using resolvable HTTP URI (see /rec/inspire-SOS/ObservationURI), one or more `gml:metaDataProperty//gml:GenericMetaData/gmd:CI_OnlineResource` elements identifying services that deliver the actual measurements SHOULD be provided.

```
…
<om:OM_Observation gml:id="o_1654042">
<gml:metaDataProperty>
     <gml:GenericMetaData>
        <gmd:CI_OnlineResource>
          <gmd:linkage>
               <gmd:URL>http://ressource.brgm-
rec.fr/service/sosRawPiezo/service=SOS&version=2.0.0&request=GetCapabilities
</gmd:URL>
          </gmd:linkage>
          <gmd:protocol>
               <gco:CharacterString>OGC:SOS-2.0.0</gco:CharacterString>
          </gmd:protocol>
        </gmd:CI_OnlineResource>
     </gml:GenericMetaData>
  </gml:metaDataProperty>
…
```

Figure 26 : Providing the online resource delivering the observation

7.1.6 Linking to monitoring facility / network

In some cases, Observations are provided but not directly linked to related Monitoring feature at which they were made. The ‘parameter’ attribute of the Observation enables to do so.

/req/inspire-om-core/relatedMonitoringFeature-parameter	To make a reference to an Environmental Monitoring Facility or an Environmental Monitoring Network from an OM_Observation, a ‘parameter’ attribute SHALL be provided, whose ‘name’ attribute is 'relatedMonitoringFeature' and whose ‘value’ attribute is the external object identifier of the referenced spatial object.

/rec/inspire-om-core/relatedMonitoringFeature-URI	In case the observation ‘parameter’ is used, its ‘value’ attribute SHOULD be a resolvable HTTP URI

```
<om:parameter>
     <om:NamedValue>
       <om:name xlink:href="relatedMonitoringFeature"/>
       <om:value                              xsi:type="gml:ReferenceType"
xlink:href="http://ressource.brgm-
rec.fr/data/Piezometre/06988C0281/F.2"/>
     </om:NamedValue>
</om:parameter>

The URI when dereferenced should provide the description of the associated
Environmental Monitoring Facility
```

Figure 27 : Linking to a monitoring Facility / network using om:parameter

7.2 External reference to an ObservationSet

When multiple observations need to be referred to as a set and when no specific offering strategy provides a satisfying approach, a dedicated FeatureType as been defined.

Detailed *ObservationSet* feature catalogue is available in "Annex D: ObservationSet "

/rec/inspire-om-core/observationSet	The ObservationSet FeatureType, or a subtype thereof, SHOULD be used to link to a set of Observations in case no offering strategy alternative is identified.

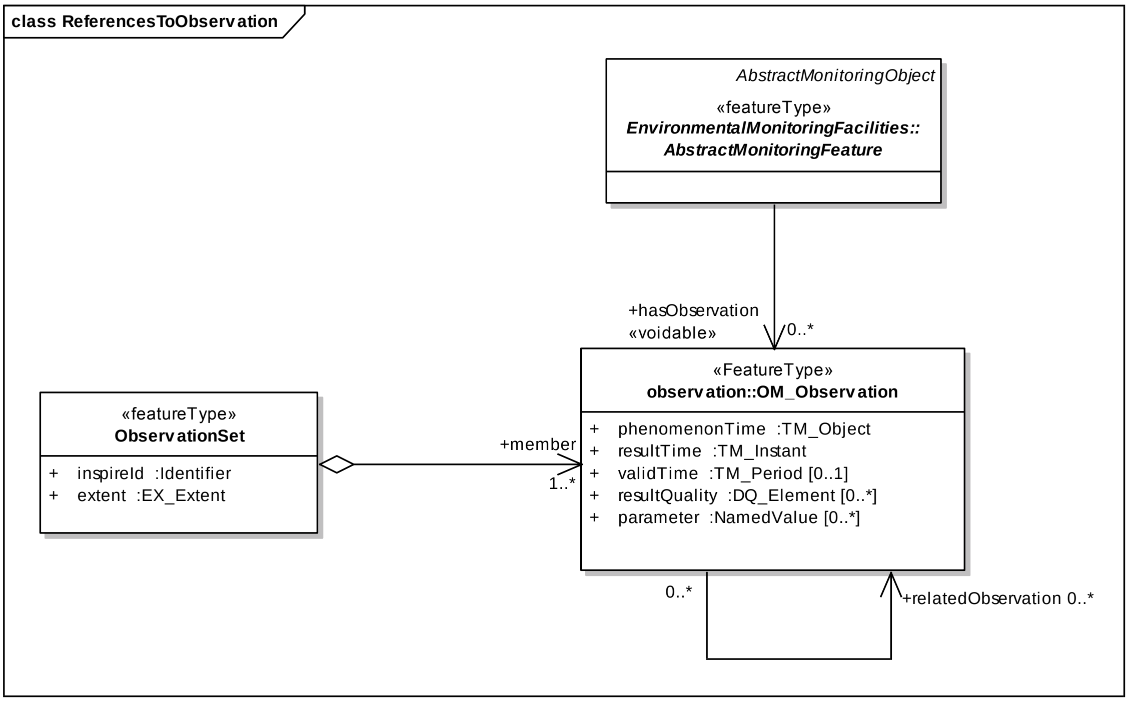
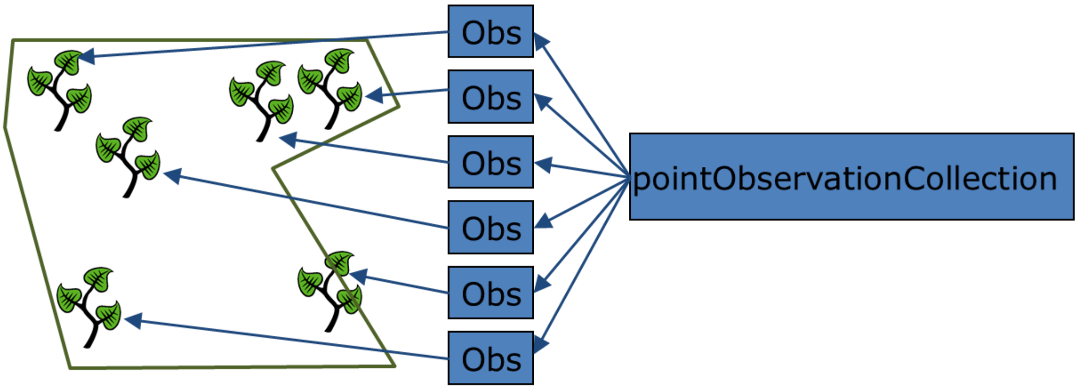


Figure 28 : Direct association to observations and observation sets

Its service implementation is provided in **/rec/inspire-SOS/ObservationSetImplementation** below.

A subtype of the ObservationSet reused in Inspire is the 'PointObservationCollection' .
An example of such case could be the set of individual observations used to determine the distribution of a species.

The grouping may be made on any basis e.g. it may be useful to group together PointObservations made by the same instrument or Environmental Facility, or in a particular measurement campaign.



<u>**Detailed '*PointObservationCollection*' feature catalogue is available in "Annex B.1.1.6 PointObservationCollection".**</u>

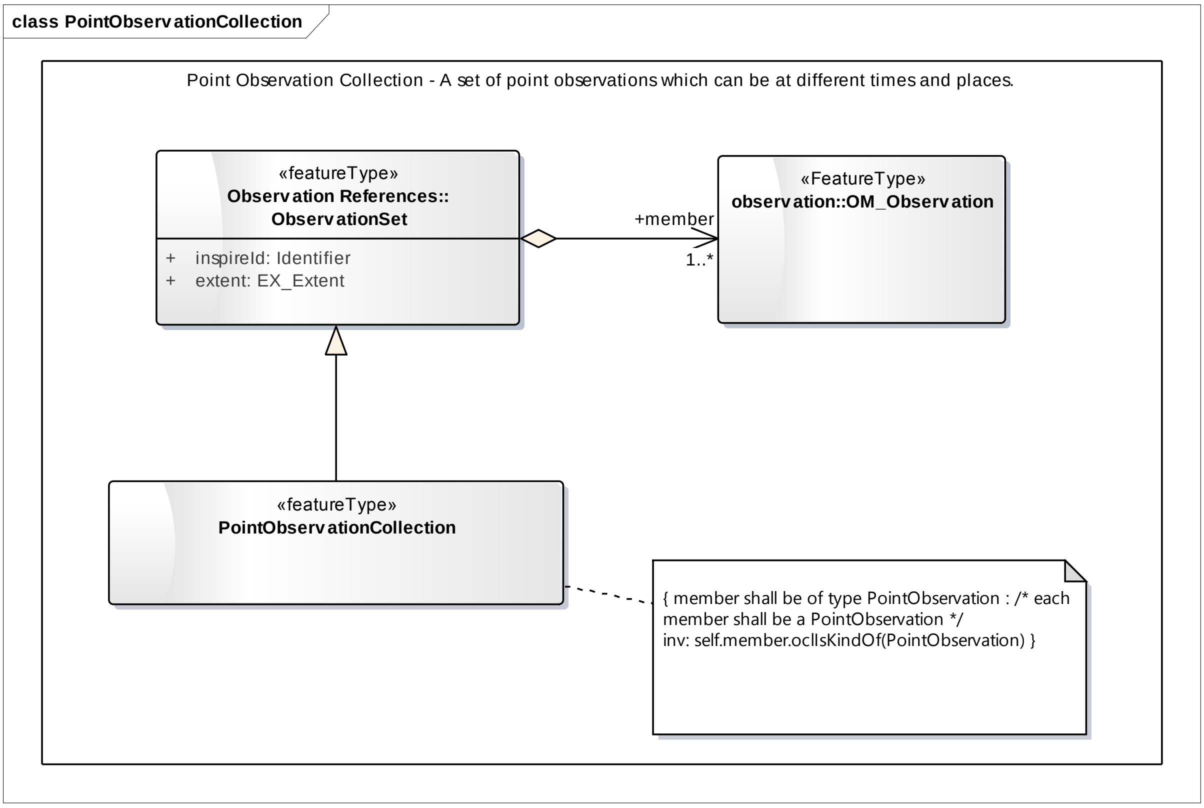


Figure 29 : PointObservationCollection

8 Web services

Requirements for the behaviour - supported operations, methods and response encodings - of web services.

Note:
In the context of INSPIRE a dedicated "Technical Guidance for implementing download services using the OGC Sensor Observation Service and ISO 19143 Filter Encoding" [INS SOS] provides requirements and recommendations.
Requirements / recommendations appearing in the following chapter that refer to one of the above will plainly make the reference with the following pattern: "[INS SOS] *TG Requirement/Recommendation x.x"*
Mentioning them here serves two purposes:
- *providing a clear overview of what these INSPIRE O&M & SWE guidelines entails from an OGC architecture perspective,*
- *while respecting INSPIRE technical guidance documents structure and allowing to map to INSPIRE terminology*

Requirements class	**/req/inspire-SOS**
Target type	Web services
Name	Capabilities of a Sensor Observation Service instance.
Dependency	http://www.opengis.net/spec/SOS/2.0/req/core
Dependency	http://www.opengis.net/spec/SOS/2.0/req/foiRetrieval
Dependency	http://www.opengis.net/spec/SOS/2.0/req/kvp-core
Dependency	http://www.opengis.net/spec/SOS/2.0/req/kvp-foiRetrieval
Recommendation	/rec/inspire-SOS/SOS
Requirement	/req/inspire-SOS/Core
Requirement	/req/inspire-SOS/SpatialFilteringProfile
Requirement	/req/inspire-SOS/XmlKVP
Recommendation	/rec/inspire-SOS/SOSGuidance
Recommendation	/rec/inspire-SOS/GetFoI
Recommendation	/rec/inspire-SOS/FoI
Requirement	/req/inspire-SOS/ObservationById
Recommendation	/rec/inspire-SOS/ObservationURI
Recommendation	/rec/inspire-SOS/GDA
Recommendation	/rec/inspire-SOS/GDAObservingCapability
Recommendation	/rec/inspire-SOS/HierarchicalOffering
Recommendation	/rec/inspire-SOS/ObservationSetImplementation
Recommendation	/rec/inspire-SOS/ServicePattern
Requirement	/req/inspire-SOS/API

8.1 Provision of O&M encoded data

The following recommendations and requirements target the the deployment of OGC Sensor Observation Service so that they provide O&M encoded data compliant with this document.

/rec/inspire-SOS/SOS	OGC Sensor Observation Service Interface Standard, Version 2.0 (OGC 12-006) SHOULD be used for the provision of O&M encoded data.

/req/inspire-SOS/Core	Implementation of a SOS download service SHALL conform to the Conformance Class 'SOS Core' ([INS SOS] TG Requirement 4.1 & 5.1)

/req/inspire-SOS/SpatialFilteringProfile	The Conformance Class 'Spatial Filtering Profile' as defined by OGC 12-006 SHALL be enabled to ensure that each observation served through the download service provides a sampling geometry. ([INS SOS] TG Requirement 4.2)

/req/inspire-SOS/XmlKVP	Implementation of an SOS dataset download service SHALL conform to the OGC 12-006 Conformance Classes 'Core KVP Binding' and 'XML Encoding'. ([INS SOS] TG Requirement 4.3 & 5.1)

/rec/inspire-SOS/SOSGuidance	When implementing SOS accompanying "Technical Guidance for implementing download services using the OGC Sensor Observation Service and ISO 19143 Filter Encoding" SHOULD be followed

/rec/inspire-SOS/GetFoI	Implementation of SOS servers to be used as INSPIRE Download Service SHOULD support the GetFeatureOfInterest operation as defined by OGC 12-006 ([INS SOS] TG Recommendation 4.3)

/rec/inspire-SOS/FoI	Implementation of SOS servers receiving a GetFeatureOfInterest request specifying the featureOfInterest, SHOULD return the identified feature gml:identifier regardless of it's observational context: domainFeature, SF_SamplingFeature subtypes and a sampledFeature

/req/inspire-SOS/ObservationById	A Direct Access Download Service SHALL implement the GetObservationByID operation as defined by OGC 12-006 ([INS SOS] TG Requirement 5.2) and use gml:identifier to provide the observation identifier.

/rec/inspire-SOS/ObservationURI	When providing a direct reference to an observation an HTTP URI through which the observation can be downloaded SHOULD be provided.

For example in INSPIRE, the "Environmental Monitoring Facilities" theme provides a 'hasObservation' association role from 'AbstractMonitoringObject' to OM_Observation.
It is advised, at the instance level, to have 'hasObservation' contain a reference that, when dereferenced, points to the dedicated offering (via a getObservation).

```
<ef:hasObservation xlink:href=" http://ressource.brgm-rec.fr/obs/RawOfferingPiezo/06988C0281/F.2" xlink:title="Raw groundwater level measurement from piezometer 06988C0281/F.2"/>
```

Figure 30 : Linking a monitoring facility/network to a SOS endpoint using a URI

8.2 Available observation data discovery

8.2.1 GetDataAvailability

An initial endeavour (OGC Sensor Observation Service 2.0 Hydrology Profile : OGC 14-004r1) defined the GetDataAvailability operation in order to provide standardized means for a client to construct valid parameter constellations (i.e. combinations of the query parameters “offering”, “procedure”, “feature of interest” and “observed property”) that refer to an existing observation.
The current profile enriched the approach. **The detailed GetDataAvailabilityV2 specification is provided in “Annex E: GetDataAvailability V2 Operation”.**

/rec/inspire-SOS/GDA	Implementation of a SOS download service SHOULD implement the GetDataAvailibilityV2 operation to test for observation availability.

Within INSPIRE, the theme III.7 Environmental Monitoring Facilities defined the concept of ObservingCapability to describe the explicit observation capability(ies) of a monitoring object; basically an observation without result (see INSPIRE *D2.8.III.7 INSPIRE Data Specification on Environmental Monitoring Facilities – Technical Guidelines)*. The mapping provided in **“Annex E: GetDataAvailability V2 Operation”, chapter “E.2 Mapping with INSPIRE ObservingCapability ”** enables to use this operation to expose such information.

/rec/inspire-SOS/GDAObservingCapability	The GetDataAvailibilityV2 operation SHOULD be used to expose the explicit capability of a Monitoring Object.

8.2.2 Hierarchical Observation Offerings

The use of a hierarchical structure of SOS observation offerings will be of help to reduce the size of the Capabilities document. This way, the GetCapabilities response would contain the more high-level Observation Offerings while the more fine-grained Observation Offerings would be accessible through the GetDataAvailability operation.
Detailed hierarchical observation offering specification is provided in “Annex F: Hierarchical Observation Offerings”.

/rec/inspire-SOS/HierarchicalOffering	Implementation of a SOS download service SHOULD implement the Hierarchical Offering extension of GetCapabilities to support offering discovery

8.2.3 External reference to an ObservationSet

The ObservationSet defined in chapter 7.2 provides a way to externally refer to a set of observations. This feature is not natively handled by the Sensor Observation Service Interface Standard in the version identified above. Thus the implementation of ObservationSet is to be implemented via WFS.

/rec/inspire-SOS/ObservationSetImplementation	Implementation of the ObservationSet FeatureType, or a subtype thereof, SHOULD be done via WFS. Its ‘member’ association role SHOULD point to a SOS endpoint for example via xlink:href to URIs through which each observation member can be downloaded directly

8.2.4 Service layer pattern

The following service pattern, illustrated from an INSPIRE perspective via the use of the “Environmental Monitoring Facilities” theme, is advised to help the discovery of available observation data.

1. Identify via a set of WFS querie(s) on the given application schema, the monitoring facilitiy or monitoring network of interest
2. Run a GetDataAvailability operation on that feature to retrieve reference(s) to candidate offering(s) that might be of interest to the user.
3. Run a GetObservation operation on the offering identifier the user whishes to retrieve observation result from.

/rec/inspire-SOS/ServicePattern	When linking a WFS server to a SOS server the pattern GetDataAvailability then GetObservation using the offering identifier as a token SHOULD be used.

8.3 Result encoding

/req/inspire-SOS/API	For all encodings that are used for all or parts of an OM_Observation result, a public Application Programming Interface (API) SHALL be available to read the encoded file. This API SHALL be capable of exposing the information needed to realise INSPIRE spatial objects.

Note:
For example, a library for a given programing language which is capable of decoding WaterML 2.0 part I result is valid API in that context

Providing out of band result is a subject by itself. It was not feasible to clarify it and come up with relevant recommendations within the timeframe of that V3.0 update.
Yet, the discussion paper provided with the previous version of D2.9 is still relevant. It is provided for information in **"Annex K: Discussion paper on Out-Of-Band Results"**

9 Expected next steps

This document is built on current agreed practices.
Observation data provision is a topic triggering many standardisation activities worldwide.
Several of them are worth mentioning and following as they might trigger enhancements in those practices; thus further revisions of this profile.

In no specific order of importance:

- SensorML 1.0.1 is kept in this technical guidance document, as it is part of the OGC SOS 2.0 specifications. Once the SOS specifications are updated with SensorML 2.0, this document should be updated accordingly.

- OGC TimeSeriesML Standards Working Group is currently developing a TimeSeriesML 1.0 candidate standard. Part of its content is in direct relation to former work on WaterML2.0–part I: Timeseries (OGC 10-126r4).

- An OGC discussion paper has recently been produced on O&M JSON encoding: OGC Observations and Measurements - JSON implementation (OGC 15-100). This might, in turn provide alternatives to light-weight data provision.

- In order to reduce the size of the sos:GetObservationResponse the use of SWE data arrays as specified in “SWE common” (*http://www.opengis.net/spec/SWE/2.0/req/uml-block-components*) and implemented in “Observations and Measurements - XML Implementation” (*http://www.opengis.net/spec/OMXML/2.0/req/SWEArrayObservation*) is another alternative.
  It is not directly specified in the current version of the Sensor Observation Service specification but can be reconstructed from the existing operations (see 11.2 Requirements Class: Result Retrieval).
  Having a direct access to this behaviour is already available (non-standard) in some SOS 2.0 implementations; specifying it is in discussion within OGC SWE Domain Working Group.

- The out of band issue addressed by the attached discussion paper is of relevance for many scientific communities generating huge content file. It needs to be finalised at some point.

- OGC SensorThings API (OGC 15-078r6) is in the process of being published (its revision number is subject to changes). It aims at providing providing an open and unified framework to interconnect IoT sensing devices, data, and applications over the Web. Its datamodel is based on Observations and Measurements (ISO 19156:2011).

- Eventually under Research Data Alliance an activity aims a providing best practices to dynamically cite subset of data (including observations): *https://www.rd-alliance.org/system/files/documents/RDA-Guidelines_TCDL_draft.pdf*

Annex B: INSPIRE specialised observations

The ‘Specialised Observations’ package defines ten specialisations of *OM_Observation*..

All the specialised Observation types essentially add ‘constraints’ to the underlying O&M model which characterise the result of the observation and the sampling regime used[3]. For example, a *PointTimeSeriesObservation* is a timeseries at a single point in space (e.g. at a fixed station), so the 'Spatial Sampling Feature' in 19156 must be a spatial sampling point, and the 'phenomenonTime' must be a time period i.e. the observation must be taken over a period of time. The type of the result must be a set of time, value pairs.

In actual fact, the specialised Observation types do not specialise *OM_Observation* directly but specialise the informative O&M class *SpecialisedCoverageObservation*, which in turn specialises *DiscreteCoverageObservation*. These two classes between them ensure that the result of the observation is a coverage, and the feature of interest is a ‘Spatial Sampling Feature’ e.g. a point, an area, a line.

[3] This pattern was modelled on the approach taken in Climate Science Modelling Language version 3 (OGC Pending Docs 11_021) which extends ISO 19156.

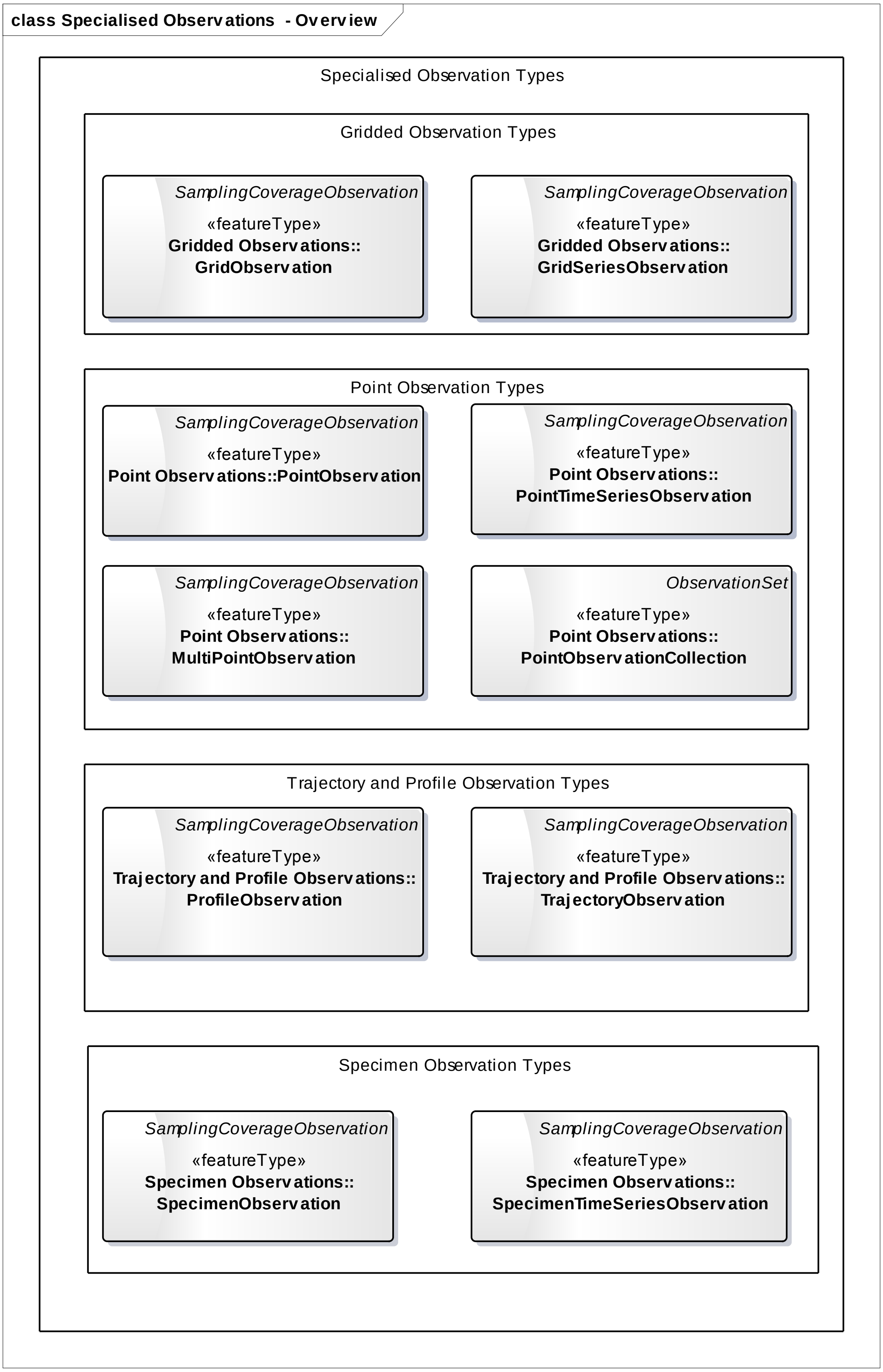


Figure 31 : Specialised Observation Types

NOTE: Specimen Observation is not explicitly stated as a spatial object type in COMMISSION REGULATION (EU) 1253/2013 implementing Directive 2007/2/EC as regards interoperability of spatial data sets and services. . The need for including it was expressed by Member State experts through the temporary MIG sub-group on SOS and O&M (MIWP-7a). They are therefore to be considered informative.

B.1 Feature catalogue – Specialised Observations (normative)

Feature catalogue metadata

Application Schema	INSPIRE Application Schema Specialised Observations
Version number	3.0

Types defined in the feature catalogue

Type	Package	Stereotypes
GridObservation	Gridded Observations	«featureType»
GridSeriesObservation	Gridded Observations	«featureType»
MultiPointObservation	Point Observations	«featureType»
PointObservation	Point Observations	«featureType»
PointObservationCollection	Point Observations	«featureType»
PointTimeSeriesObservation	Point Observations	«featureType»
ProfileObservation	Trajectory and Profile Observations	«featureType»
TimeLocationValueTriple	Trajectory and Profile Observations	«dataType»
TrajectoryObservation	Trajectory and Profile Observations	«featureType»

B.1.1 *Spatial object types*

B.1.1.1 GridObservation

GridObservation	
Name:	GridObservation
Subtype of:	SamplingCoverageObservation
Definition:	Observation representing a gridded field at a single time instant.
Description:	A GridObservation is an observation of some phenomenon (or phenomena) over a gridded field. E.g. Output from a model, or rectified, georeferenced satellite data. The result of a GridObservation is a discrete coverage within a compound spatiotemporal CRS where the domain consists of a two- or three-dimensional grid of points, all having the same time instant temporal component.
Stereotypes:	«featureType»
Constraint: featureOfInterest must be a SF_SamplingSolid or SF_SamplingSurface	
Natural language:	featureOfInterest must be a SF_SamplingSolid or SF_SamplingSurface
OCL:	inv: self.featureOfInterest->forAll(oclIsKindOf(SF_SamplingSolid)) OR inv: self.featureOfInterest->forAll(oclIsKindOf(SF_SamplingSurface))
Constraint: phenomenonTime must be a TM_Instant	
Natural language:	phenomenonTime must be a TM_Instant
OCL:	inv: self.phenomenonTime.oclIsKindOf(TM_Instant)
Constraint: result must be a RectifiedGridCoverage or ReferenceableGridCoverage	
Natural language:	result must be a RectifiedGridCoverage or RefererencableGridCoverage

GridObservation	
OCL:	inv: self.result.oclIsKindOf(RectifiedGridCoverage) OR self.result.oclIsKindOf(ReferenceableGridCoverage)

B.1.1.2 GridSeriesObservation

GridSeriesObservation	
Name:	GridSeriesObservation
Subtype of:	SamplingCoverageObservation
Definition:	Observation representing an evolving gridded field at a succession of time instants.
Description:	A GridSeriesObservation is a time series of gridded fields representing the same phenomenon (or phenomena) over a series of times. E.g. Ocean model output. The result of a GridSeriesObservation is a discrete coverage within a compound spatiotemporal CRS where the domain consists of a series of two- or three-dimensional grids of points, each at a successive time instant.
Stereotypes:	«featureType»
Constraint: featureOfInterest must be a SF_SamplingSolid	
Natural language:	featureOfInterest must be a SF_SamplingSolid
OCL:	inv: self.featureOfInterest->forAll(oclIsKindOf(SF_SamplingSolid))
Constraint: One of the axes of the domain must be a temporal axis.	
Natural language:	
OCL:	
Constraint: phenomenonTime must be a TM_Period	
Natural language:	phenomenonTime must be a TM_Period
OCL:	inv: self.phenomenonTime.oclIsKindOf(TM_Period)
Constraint: result must be a RectifiedGridCoverage or ReferenceableGridCoverage	
Natural language:	result must be a RectifiedGridCoverage or a ReferenceableGridCoverage
OCL:	inv: self.result.oclIsKindOf(RectifiedGridCoverage) OR self.result.oclIsKindOf(ReferenceableGridCoverage)

B.1.1.3 PointObservation

PointObservation	
Name:	Point Observation
Subtype of:	SamplingCoverageObservation
Definition:	Observation that represents a measurement of a property at a single point in time and space.
Description:	The PointObservation represents a single measurement or estimation of a property at a single point in time and space. For example a single temperature measurement at a fixed weather station.
Stereotypes:	«featureType»
Constraint: featureOfInterest must be a SF_SamplingPoint	
Natural language:	featureOfInterest must be a SF_SamplingPoint
OCL:	inv: self.featureOfInterest->forAll(oclIsKindOf(SF_SamplingPoint))
Constraint: phenomenonTime must be a TM_Instant	

PointObservation	
Natural language:	phenomenonTime must be a TM_Instant
OCL:	inv: self.phenomenonTime.oclIsKindOf(TM_Instant)
Constraint: result must be a CV_DiscretePointCoverage	
Natural language:	result must be a CV_DiscretePointCoverage
OCL:	inv: self.result.oclIsKindOf(CV_DiscretePointCoverage)

B.1.1.4 MultiPointObservation

MultiPointObservation	
Name:	MultiPointObservation
Subtype of:	SamplingCoverageObservation
Definition:	Observation that represents a set of measurements all made at exactly the same time but at different locations
Description:	The MultiPointObservation is an Observation that represents a set of measurements of the same observed property all made at exactly the same time but at different locations, for example a distributed sensor network reporting the temperature at 10am. The result of this observation is a MultiPointCoverage.
Stereotypes:	«featureType»
Constraint: featureOfInterest shall be a SF_SamplingSurface	
Natural language:	featureOfInterest must be a SF_SamplingSurface
OCL:	inv: self.featureOfInterest->forAll(oclIsKindOf(SF_SamplingSurface))
Constraint: phenomenonTime shall be a TM_Instant	
Natural language:	phenomenonTime must be a TM_Instant
OCL:	inv: self.phenomenonTime.oclIsKindOf(TM_Instant)
Constraint: result must be a MultiPointCoverage	
Natural language:	result must be a MultiPointCoverage
OCL:	inv: self.result.oclIsKindOf(MultiPointCoverage)

B.1.1.5 PointTimeSeriesObservation

PointTimeSeriesObservation	
Name:	PointTimeSeriesObservation
Subtype of:	SamplingCoverageObservation
Definition:	Observation that represents a time-series of point measurements of a property at a fixed location in space
Description:	A PointTimeSeriesObservation is a time series of observations made at the same fixed spatial location e.g. Measurements made repeatedly by a fixed monitoring instrument.
Stereotypes:	«featureType»
Constraint: featureOfInterest must be a SF_SamplingPoint	
Natural language:	featureOfInterest must be a SF_SamplingPoint
OCL:	inv: self.featureOfInterest->forAll(oclIsKindOf(SF_SamplingPoint))
Constraint: phenomenonTime must be a TM_Period	
Natural language:	phenomenonTime must be a TM_Period

PointTimeSeriesObservation	
OCL:	inv: self.phenomenonTime.oclIsKindOf(TM_Period)
Constraint: result must be a TimeSeries	
Natural language:	result must be a Timeseries
OCL:	inv: self.result.oclIsKindOf(TimeSeries)

B.1.1.6 PointObservationCollection

PointObservationCollection	
Name:	PointObservationCollection
Subtype of:	ObservationSet
Definition:	A collection of Point Observations.
Description:	The PointObservationCollection is a collection of separate PointObservations. In the case where it is useful to group together a set of otherwise independent PointObservations the PointObservationCollection should be used to make this grouping. The grouping may be made on any basis e.g. it may be useful to group together PointObservations made by the same instrument or Environmental Facility, or in a particular measurement campaign. Each member of the PointObservationCollection must be a single PointObservation.
Stereotypes:	«featureType»
Constraint: member shall be of type PointObservation	
Natural language:	each member shall be a PointObservation
OCL:	inv: self.member.oclIsKindOf(PointObservation)

B.1.1.7 ProfileObservation

ProfileObservation	
Name:	ProfileObservation
Subtype of:	SamplingCoverageObservation
Definition:	Observation representing the measurement of a property along a vertical profile in space at a single time instant.
Description:	A ProfileObservation is an Observation representing the measurement of a property along a vertical profile in space at a single time instant. For example a CTD profile measuring salinity at different depths in the ocean.
Stereotypes:	«featureType»
Constraint: featureOfInterest must be a SF_SamplingCurve	
Natural language:	featureOfInterest must be a SF_SamplingCurve
OCL:	inv: self.featureOfInterest->forAll(oclIsKindOf(SF_SamplingCurvet))
Constraint: phenomenonTime must be a TM_Instant	
Natural language:	phenomenonTime must be a TM_Instant
OCL:	inv: self.phenomenonTime.oclIsKindOf(TM_Instant)
Constraint: result must be a ReferenceableGridCoverage or RectifiedGridCoverage	
Natural language:	result must be a ReferenceableGridCoverage or a RectifiedGridCoverage
OCL:	inv: self.result.oclIsKindOf(ReferenceableGridCoverage) OR inv: self.result.oclIsKindOf(RectifiedGridCoverage)
Constraint: spatial domain of the result shall contain one axis and that shall be vertical	

ProfileObservation	
Natural language:	
OCL:	

B.1.1.8 TrajectoryObservation

TrajectoryObservation	
Name:	TrajectoryObservation
Subtype of:	SamplingCoverageObservation
Definition:	Observation representing the measurement of a property along a meandering curve in time and space.
Description:	A TrajectoryObservation is an Observation representing the measurement of a property along a curve in time and space. For example a Pollutant concentration from a mobile air quality sensor.
Stereotypes:	«featureType»
Constraint: featureOfInterest must be a SF_SamplingCurve	
Natural language:	featureOfInterest must be a SF_SamplingPoint
OCL:	inv: self.featureOfInterest->forAll(oclIsKindOf(SF_SamplingPoint))
Constraint: phenomenonTime must be a TM_Period	
Natural language:	phenomenonTime must be a TM_Period
OCL:	inv: self.phenomenonTime.oclIsKindOf(TM_Period)
Constraint: result must be a TimeSeries	
Natural language:	result must be a Timeseries
OCL:	inv: self.result.oclIsKindOf(TimeSeries)
Constraint: result.point must be TimeLocationValueTriple	
Natural language:	each point in the result must be a TimeLocationValueTriple
OCL:	inv: self.result.point.oclIsKindOf(TimeLocationValueTriple)

B.1.2 *Data types*

B.1.2.1 TimeLocationValueTriple

TimeLocationValueTriple	
Name:	TimeLocationValue Triple
Subtype of:	AnnotatedTimeValuePair
Definition:	A triple set of Time, location, value (measurement). For example, at a point along a trajectory.
Stereotypes:	«dataType»
Attribute: location	
Name:	location
Value type:	GM_Position
Definition:	Geographic location where value is valid.
Multiplicity:	1

B.1.3 *Imported types (informative)*

This section lists definitions for feature types, data types, enumerations and code lists that are defined in other application schemas. The section is purely informative and should help the reader understand the feature catalogue presented in the previous sections. For the normative documentation of these types, see the given references.

B.1.3.1 AnnotatedTimeValuePair

AnnotatedTimeValuePair	
Package:	Timeseries
Reference:	Taylor, Peter (ed.), OGC® WaterML Encoding Standard, version 2.0.0, Open Geospatial Consortium, 2012 [OGC 10-126r3]

B.1.3.2 GM_Position

GM_Position	
Package:	Coordinate geometry
Reference:	Geographic information -- Spatial schema [ISO 19107:2003]

B.1.3.3 ObservationSet

ObservationSet	
Package:	Observation References
Reference:	Guidelines for the use of Observations & Measurements and Sensor Web Enablement-related standards in INSPIRE [DS-D2.9]
Definition:	Links a set of Observations
Description:	This class is used to link multiple related Observations together

B.1.3.4 SamplingCoverageObservation

SamplingCoverageObservation	
Package:	Sampling Coverage Observation
Reference:	Geographic information -- Observations and measurements [ISO/TS 19156:2011]

B.2 Feature catalogue – Specialised Observations. Extension (informative)

NOTE: Specimen Observation is not explicitly stated as a spatial object type in COMMISSION REGULATION (EU) 1253/2013 implementing Directive 2007/2/EC as regards interoperability of spatial data sets and services. . The need for including it was expressed by Member State experts through the temporary MIG sub-group on SOS and O&M (MIWP-7a). They are therefore to be considered informative.

Feature catalogue metadata

Application Schema	INSPIRE Application Schema Specialised Observations. Extension
Version number	1.0

Types defined in the feature catalogue

Type	Package	Stereotypes
SpecimenObservation	Specimen Observations	«featureType»
SpecimenTimeSeriesObservation	Specimen Observations	«featureType»

B.2.1.1 SpecimenObservation

SpecimenObservation	
Name:	Specimen Observation
Subtype of:	SamplingCoverageObservation
Definition:	Observation that represents a measurement of a property of a Specimen at a single point in time.
Description:	The SpecimenObservation represents a single measurement or estimation of a property of a Specimen at a single point in time. For example the Nitrate concentration of a water sample taken from a lake.
Stereotypes:	«featureType»
Constraint: featureOfInterest must be a SF_Specimen	
Natural language:	featureOfInterest must be a SF_Specimen
OCL:	inv: self.featureOfInterest->forAll(oclIsKindOf(SF_Specimen))
Constraint: SF_Specimen samplingLocation is mandatory	
Natural language:	SF_Specimen samplingLocation is mandatory
OCL:	inv: featureOfInterest.SF_Specimen.samplingLocation -> notEmpty()
Constraint: phenomenonTime must be a TM_Instant	
Natural language:	phenomenonTime must be a TM_Instant
OCL:	inv: self.phenomenonTime.oclIsKindOf(TM_Instant)
Constraint: result must be a CV_DiscretePointCoverage	
Natural language:	result must be a CV_DiscretePointCoverage
OCL:	inv: self.result.oclIsKindOf(CV_DiscretePointCoverage)

B.2.1.2 SpecimenTimeSeriesObservation

SpecimenTimeSeriesObservation	
Name:	SpecimenTimeSeriesObservation
Subtype of:	SamplingCoverageObservation
Definition:	Observation that represents a time-series of point measurement of a property of a Specimen analysed at regular intervals

SpecimenTimeSeriesObservation	
Description:	The SpecimenTimeSeriesObservation represents a time series of observations on a Specimen made repeatedly with the same procedure.
Stereotypes:	«featureType»
Constraint: featureOfInterest must be a SF_Specimen	
Natural language:	featureOfInterest must be a SF_Specimen
OCL:	inv: self.featureOfInterest->forAll(oclIsKindOf(SF_Specimen))
Constraint: SF_Specimen samplingLocation is mandatory	
Natural language:	SF_Specimen samplingLocation is mandatory
OCL:	inv: featureOfInterest.SF_Specimen.samplingLocation -> notEmpty()
Constraint: phenomenonTime must be a TM_Period	
Natural language:	phenomenonTime must be a TM_Period
OCL:	inv: self.phenomenonTime.oclIsKindOf(TM_Period)
Constraint: result must be a TimeSeries	
Natural language:	result must be a Timeseries
OCL:	inv: self.result.oclIsKindOf(TimeSeries)

B.3 wml2: MeasurementTimeseries implementation (informative)

The following is taken from *http://schemas.opengis.net/waterml/2.0/timeseries.xsd*

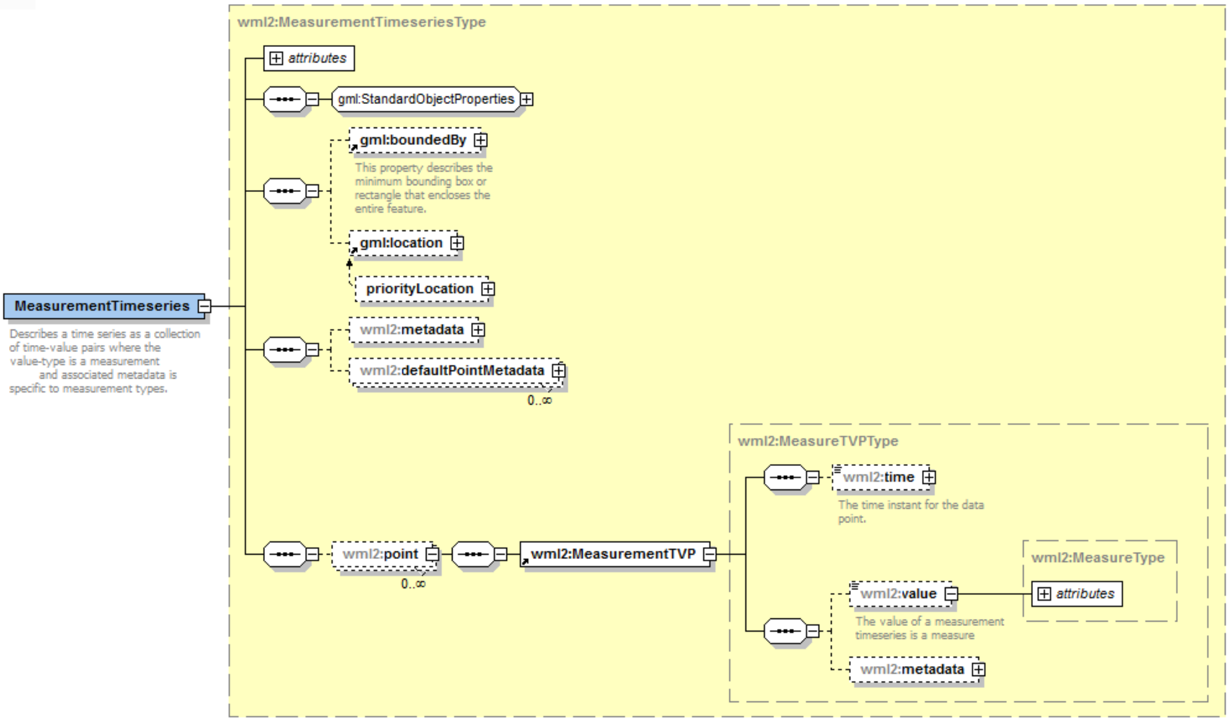


Figure 32 : wml2:MeasurementTimeseries

Annex C: INSPIRE Process

C.1 Feature Catalogue (normative)

Feature catalogue metadata

Application Schema	INSPIRE Application Schema Processes
Version number	2.0

Types defined in the feature catalogue

Type	Package	Stereotypes
Process	Processes	«featureType»
ProcessParameter	Processes	«dataType»

C.1.1 *Spatial object types*

C.1.1.1 Process

Process	
Name:	Process
Subtype of:	OM_Process
Definition:	Description of an observation process
Stereotypes:	«featureType»
Attribute: documentation	
Name:	documentation
Value type:	DocumentCitation
Definition:	Further information (online/offline) associated with the process .
Multiplicity:	0..*
Stereotypes:	«voidable»
Attribute: inspireId	
Name:	inspireId
Value type:	Identifier
Definition:	External object identifier of the spatial object.
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: name	
Name:	name
Value type:	CharacterString
Definition:	Name of the Process
Multiplicity:	0..1
Stereotypes:	«voidable»
Attribute: processParameter	
Name:	process parameter
Value type:	ProcessParameter
Definition:	Parameter controlling the application of the process and as a consequence its output.

Process

Description:	Typical examples of using processParameter are: description of instrumentation settings for a specific measurement or measurement series ; description of intial contidions in numerical computations e.g. simulations. NOTE The values of a procesParameter are stored in OM_Observation.parameter>NamedValue.value as they are specific to the event of the observation and not to the applied process . The relevant OM_Observation.parameter>NamedValue.name shall be the same with Process.processParameter>ProcessParameter.name. EXAMPLE Analysis time of a forecast • Instance of Process Process.processParameter>ProcessParameter.name: *http://inspire.jrc.ec.europa.eu/inspire/processParameterValue.html#AnalysisTime* • Instance of OM_Observation OM_Observation.parameter>NamedValue.name: *http://inspire.jrc.ec.europa.eu/inspire/processParameterValue.html#AnalysisTime* OM_Observation.parameter>NamedValue.value: *00z-15/05/2011*
Multiplicity:	0..*
Stereotypes:	«voidable»

Attribute: responsibleParty

Name:	responsible party
Value type:	RelatedParty
Definition:	Individual or organisation related to the process.
Description:	EXAMPLE For a numerical simulation a responsible party may be the NWP centre which conducted the simulation
Multiplicity:	1..*
Stereotypes:	«voidable»

Attribute: type

Name:	type
Value type:	CharacterString
Definition:	Type of process.
Description:	EXAMPLE raingauge, numerical model.
Multiplicity:	1
Stereotypes:	«voidable»

C.1.2 *Data types*

C.1.2.1 ProcessParameter

ProcessParameter

Name:	Process Parameter
Definition:	Description of the given parameter
Stereotypes:	«dataType»

Attribute: description

Name:	description
Value type:	CharacterString
Definition:	Description of the process parameter.

ProcessParameter	
Multiplicity:	0..1

Attribute: name

Name:	name
Value type:	ProcessParameterNameValue
Definition:	Name of the process parameter.
Multiplicity:	1
Values:	The allowed values for this code list comprise any values defined by data providers.

C.1.3 *Code lists*

C.1.3.1 ProcessParameterNameValue

ProcessParameterNameValue	
Name:	Process Parameter Name Value
Definition:	A code list of names of process parameters.
Description:	This code list itself is an empty placeholder and should be extended and specified for any thematic domain.
Extensibility:	any
Identifier:	
Values:	The allowed values for this code list comprise any values defined by data providers.

C.1.4 *Imported types (informative)*

This section lists definitions for feature types, data types, enumerations and code lists that are defined in other application schemas. The section is purely informative and should help the reader understand the feature catalogue presented in the previous sections. For the normative documentation of these types, see the given references.

C.1.4.1 CharacterString

CharacterString	
Package:	Text
Reference:	Geographic information -- Conceptual schema language [ISO/TS 19103:2005]

C.1.4.2 DocumentCitation

DocumentCitation	
Package:	Base Types 2
Reference:	INSPIRE Generic Conceptual Model, version 3.4 [DS-D2.5]
Definition:	Citation for the purposes of unambiguously referencing a document.

C.1.4.3 Identifier

Identifier	
Package:	Base Types
Reference:	INSPIRE Generic Conceptual Model, version 3.4 [DS-D2.5]
Definition:	External unique object identifier published by the responsible body, which may be used by external applications to reference the spatial object.
Description:	NOTE1 External object identifiers are distinct from thematic object identifiers. NOTE 2 The voidable version identifier attribute is not part of the unique identifier of a spatial object and may be used to distinguish two versions of the same spatial object. NOTE 3 The unique identifier will not change during the life-time of a spatial object.

C.1.4.4 RelatedParty

RelatedParty	
Package:	Base Types 2
Reference:	INSPIRE Generic Conceptual Model, version 3.4 [DS-D2.5]
Definition:	An organisation or a person with a role related to a resource.
Description:	NOTE 1 A party, typically an individual person, acting as a general point of contact for a resource can be specified without providing any particular role.

C.2 Process Encoding with SensorML 1.0.1 (informative)

C.2.1 *Mapping to SensorML*

INSPIRE Attribute & Datatype	SensorML XPath
documentation : DocumentCitation	
name	…/sml:documentation/sml:Document/gml:description
shortName	NA
date	…/sml:documentation/sml:Document/sml:date
link	…/sml:documentation/sml:Document/sml:onlineResource/@xlink:href
inspireId : Identifier	*NOTE The inspireId should be provided in an individual IdentifierList entry. The identifier should carry the name inspireId*. …/sml:identification[1]/sml:IdentifierList/sml:identifier/@name = inspireId
localId	…/sml:identification/sml:IdentifierList/sml:identifier/sml:Term/sml:value
namespace	…/sml:identification/sml:IdentifierList/sml:identifier/sml:Term/sml:codeSpace/@xlink:href
versionId	
name : CharacterString	…/sml:identification/sml:IdentifierList/sml:identifier/sml:Term/sml:value …/sml:identification/sml:IdentifierList/sml:identifier/@name = procedureName
processParameter : ProcessParameter	*NOTE The pair of name and description for one process parameter must always be grouped together in one ClassifierList*
description	…/sml:classification/sml:ClassifierList/sml:classifier/sml:Term …/sml:classification/sml:ClassifierList/sml:classifier/@name = description
name	…/sml:classification/sml:ClassifierList/sml:classifier/sml:Term/sml:value …/sml:classification/sml:ClassifierList/sml:classifier/@name = name
responsibleParty : RelatedParty	…/sml:contact/sml:ResponsibleParty
type : CharacterString	…/sml:classification/sml:ClassifierList/sml:classifier/sml:Term/sml:value

NOTE All XPaths should start with "/sml:SensorML/sml:member/sml:Component", for brevity this has been reduced to "…"

C.2.2 *Example*

The following section applies the mapping depicted in the previous chapter and show how an INSPIRE Process can be encoded using OGC SensorML 1.0.1.

```
<?xml version="1.0" encoding="UTF-8"?>
```

```
<sml:SensorML                                             version="1.0.1"
xmlns:sml="http://www.opengis.net/sensorML/1.0.1"
xmlns:gml="http://www.opengis.net/gml"
xmlns:xlink="http://www.w3.org/1999/xlink"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://www.opengis.net/sensorML/1.0.1
http://schemas.opengis.net/sensorML/1.0.1/system.xsd">
  <sml:member>
    <sml:Component>
      <sml:identification>
        <sml:IdentifierList>
            <sml:identifier name="inspireID">
            <sml:Term>
              <sml:codeSpace xlink:href="namespace"/>
              <sml:value>identifier</sml:value>
            </sml:Term>
            </sml:identifier>
        </sml:IdentifierList>
      </sml:identification>
      <sml:identification>
        <sml:IdentifierList>
            <sml:identifier name="procedureName">
            <sml:Term>
              <sml:value>procedureName</sml:value>
            </sml:Term>
            </sml:identifier>
        </sml:IdentifierList>
      </sml:identification>
      <sml:classification>
        <sml:ClassifierList>
            <sml:classifier name="type">
            <sml:Term>
              <sml:value>procedureType, i.e. "raingauge"</sml:value>
            </sml:Term>
            </sml:classifier>
        </sml:ClassifierList>
      </sml:classification>
      <sml:classification>
        <sml:ClassifierList>
            <sml:classifier name="description">
            <sml:Term>
              <sml:value>o  the water hardness of the river being sampled
from</sml:value>
            </sml:Term>
            </sml:classifier>
            <sml:classifier name="name">
            <sml:Term>
              <sml:value>WaterHardness</sml:value>
            </sml:Term>
            </sml:classifier>
        </sml:ClassifierList>
      </sml:classification>
      <sml:contact>
        <sml:ResponsibleParty>
            <sml:individualName>Alexandre Robin</sml:individualName>
            <sml:organizationName>University      of      Alabama      in
Huntsville</sml:organizationName>
            <sml:positionName>Research Scientist</sml:positionName>
            <sml:contactInfo>
            <sml:phone>
```

```
                <sml:voice>(256)9617978</sml:voice>
              </sml:phone>
              <sml:address>
  <sml:electronicMailAddress>robin@nsstc.uah.edu</sml:electronicMailAddress
>
              </sml:address>
              </sml:contactInfo>
          </sml:ResponsibleParty>
        </sml:contact>
        <sml:documentation>
          <sml:Document>
              <gml:description>Description of Process</gml:description>
              <sml:date>2010-12-02</sml:date>
              <sml:onlineResource
xlink:href="http://www.umweltbundesamt.at/"/>
          </sml:Document>
        </sml:documentation>
      </sml:Component>
  </sml:member>
</sml:SensorML>
```

Figure 33 : INSPIRE Process featureType encoded in SensorML 1.0.1 example

Annex D: ObservationSet

D.1 Feature Catalogue (normative)

Feature catalogue metadata

Application Schema	INSPIRE Application Schema Observation References
Version number	2.0

Types defined in the feature catalogue

Type	Package	Stereotypes
ObservationSet	Observation References	«featureType»

D.1.1 *Spatial object types*

D.1.1.1 ObservationSet

ObservationSet	
Name:	ObservationSet
Definition:	Links a set of Observations
Description:	This class is used to link multiple related Observations together
Stereotypes:	«featureType»
Attribute: extent	
Name:	extent
Value type:	EX_Extent
Definition:	Information about the spatial and temporal extent.
Multiplicity:	1
Attribute: inspireId	
Name:	inspireId
Value type:	Identifier
Definition:	External object identifier of the spatial object.
Multiplicity:	1
Association role: member	
Name:	member
Value type:	OM_Observation
Definition:	One member of the ObservationSet
Multiplicity:	1..*

D.1.2 *Imported types (informative)*

This section lists definitions for feature types, data types, enumerations and code lists that are defined in other application schemas. The section is purely informative and should help the reader understand the feature catalogue presented in the previous sections. For the normative documentation of these types, see the given references.

D.1.2.1 EX_Extent

EX_Extent	
Package:	Extent information
Reference:	Geographic information -- Metadata [ISO 19115:2003/Cor 1:2006]

D.1.2.2 Identifier

Identifier	
Package:	Base Types
Reference:	INSPIRE Generic Conceptual Model, version 3.4 [DS-D2.5]
Definition:	External unique object identifier published by the responsible body, which may be used by external applications to reference the spatial object.
Description:	NOTE1 External object identifiers are distinct from thematic object identifiers. NOTE 2 The voidable version identifier attribute is not part of the unique identifier of a spatial object and may be used to distinguish two versions of the same spatial object. NOTE 3 The unique identifier will not change during the life-time of a spatial object.

Annex E: GetDataAvailability V2 Operation (normative)

This section describes GetDataAvailability V2 as enriched by INSPIRE. The term ‘V2’ is kept on purpose to distinguish the current enrichment from the initial specification of GetDataAvailabity according to “OGC Sensor Observation Service 2.0 Hydrology Profile” (OGC 14-004r1).

Only additional elements to the initial GetDataAvailabity specification are described here.

E.1 Operation specification

E.1.1 *Request*

One element is added to the initial specification.

Element	Description	Cardinality
responseFormat	The responseFormat in which the response should be encoded. Either “*http://www.opengis.net/sosgda/1.0*” or “*http://www.opengis.net/sosgda/2.0*”	0..*

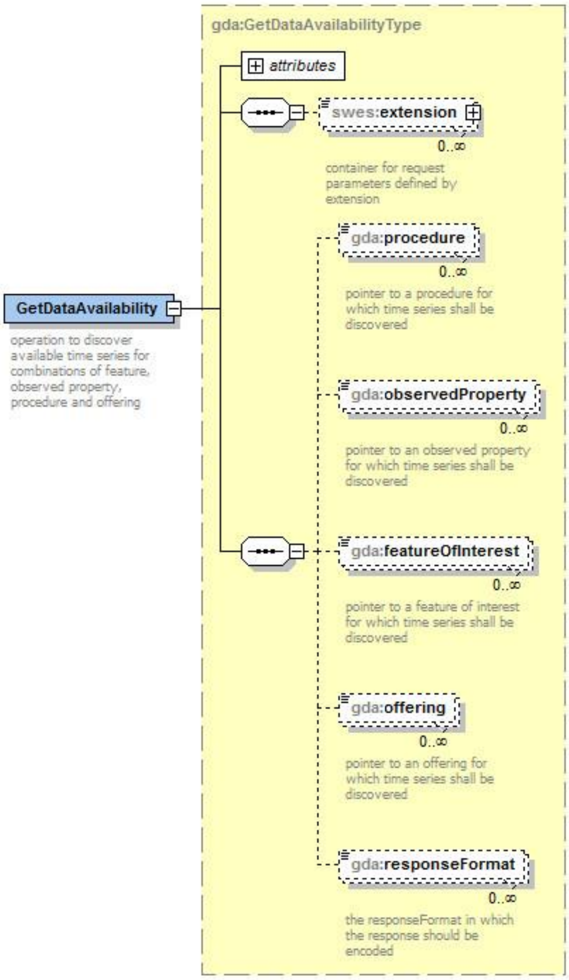


Figure 34 : GetDataAvailability operation specification

E.1.2 *Response*

Initial GetDataAvailability response is extended with the following

Element	Description	Cardinality
offering	Reference to the offering (anyURI)	0..1
formatDescriptor	Contains the following elements: • One procedureDescriptionFormatDescriptor element containing information about the supported procedure description format. • One or multiple observationFormatDescriptorelements containing information about the supported response format and observation typesfor this response format	0..1

The formatDescriptor contains the following elements:

Element	Description	Cardinality
procedureDescriptionFormatDescriptor	Contains a procedureDescriptionFormat element containing a URI identifying the procedure description format	1..1
observationFormatDescriptor	Contains the following elements: • One responseFormat element containing a URI identifying the response format • One or multiple observationType elements containing one URI identifying the observation types supported for this response format	1..*

Both elements specification overview schema are provided in the following pages.

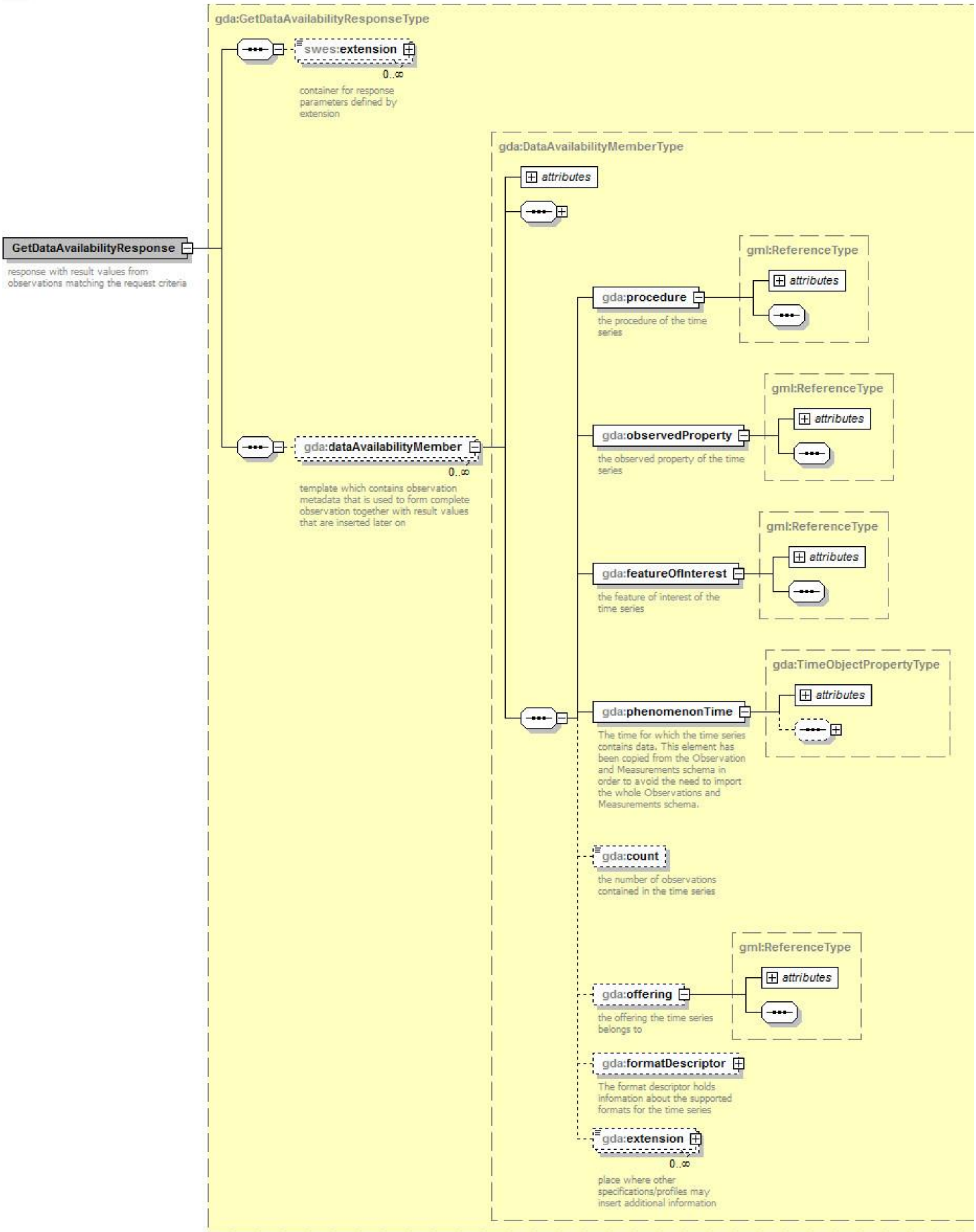


Figure 35: GetDataAvailabilityResponse specification

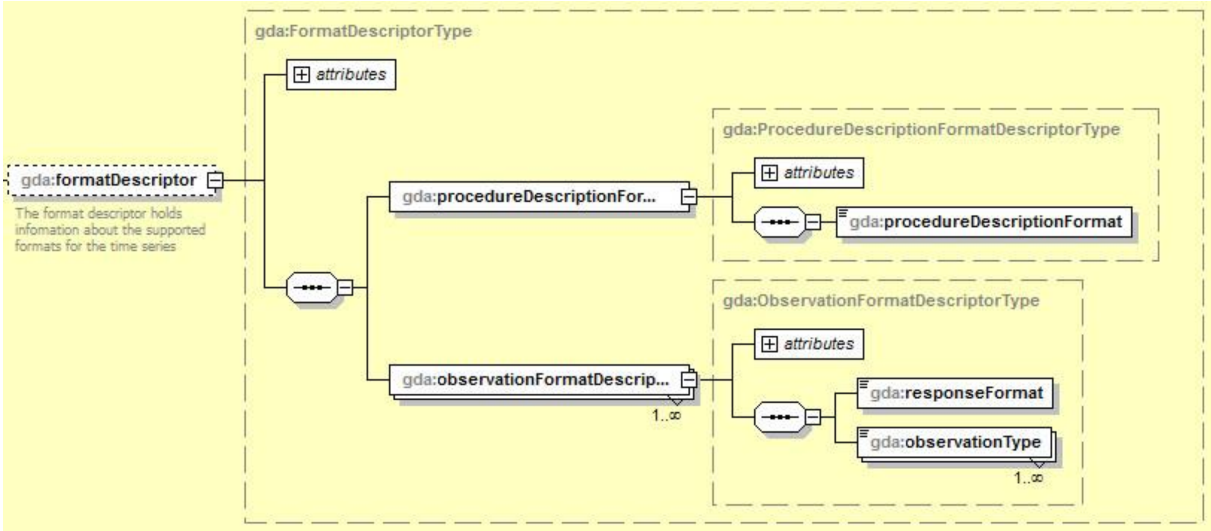


Figure 36: formatDescriptor specification

The following shows the example of a GetDataAvailability V2 response to the GetDataAvailability request on the observedProperty ‘GroundWaterLevel depth’ (code *http://id.eaufrance.fr/par/1689.xml* in the French Water Information System).

```
<gda:GetDataAvailabilityResponse xmlns:gda="http://www.opengis.net/sosgda/2.0"
xmlns:gml="http://www.opengis.net/gml/3.2"
xmlns:swe="http://www.opengis.net/swe/2.0"
xmlns:xlink="http://www.w3.org/1999/xlink"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://inspire.ec.europa.eu/schemas/ef/4.0
http://inspire.ec.europa.eu/schemas/ef/4.0/EnvironmentalMonitoringFacilities.xsd
http://www.opengis.net/sosgda/2.0 http://waterml2.org/schemas/gda/2.0/gda.xsd">
   <gda:dataAvailabilityMember gml:id="dam_1">
      <gda:procedure xlink:href="http://id.eaufrance.fr/met/403.xml"
xlink:title="Electronic piezometric probe"/>
      <gda:observedProperty xlink:href="http://id.eaufrance.fr/par/1689.xml"
xlink:title="GroundWaterLevel depth"/>
      <gda:featureOfInterest xlink:href="http://ressource.brgm-
rec.fr/data/Piezometre/06988C0281/F.2" xlink:title=" Piézomètre molasse piscine
chassieu - 69"/>
      <gda:phenomenonTime>
         <gml:TimePeriod gml:id="tp_1">
            <gml:beginPosition>2016-01-05T15:00:00.000Z</gml:beginPosition>
            <gml:endPosition>2016-06-16T14:00:00.000Z</gml:endPosition>
         </gml:TimePeriod>
      </gda:phenomenonTime>
      <gda:count>3433</gda:count>
      <gda:offering>http://ressource.brgm-
rec.fr/obs/RawOfferingPiezo/06988C0281/F.2</gda:offering>
      <gda:formatDescriptor>
         <gda:procedureDescriptionFormatDescriptor>

   <gda:procedureDescriptionFormat>http://inspire.ec.europa.eu/featureconcept/Proces
s</gda:procedureDescriptionFormat>
         </gda:procedureDescriptionFormatDescriptor>
         <gda:observationFormatDescriptor>

   <gda:responseFormat>http://inspire.ec.europa.eu/schemas/omso/3.0</gda:responseFor
mat>

   <gda:observationType>http://inspire.ec.europa.eu/featureconcept/PointTimeSeriesOb
servation</gda:observationType>
         </gda:observationFormatDescriptor>
```

```
      </gda:formatDescriptor>
      <gda:extension name="inspireExtension">
         <om:NamedValue xmlns:om="http://www.opengis.net/om/2.0">
            <om:name xlink:href="resultNature" />
            <om:value xsi:type="gml:ReferenceType" 
xlink:href="http://inspire.ec.europa.eu/codelist/ResultNatureValue/primary"/>
         </om:NamedValue>
      </gda:extension>
   </gda:dataAvailabilityMember>
   <gda:dataAvailabilityMember gml:id="dam_2">
…
```

Figure 37 : GetDataAvailability V2 reponse example

E.2 Mapping with INSPIRE ObservingCapability

The proposed mapping enables to use GetDataAvailability V2 as a way to provide INSPIRE ObservingCapability as defined in the theme III.7 Environmental Monitoring Facilities.

		GDA V2 response						
						formatDescriptor		gda:extension name= "inspireExtension"
	Name	procedure	observedProperty	featureOfInterest	phenomenonTime	procedureDescription FormatDescriptor	observationFormat Descriptor	
INSPIRE Observing Capability	observingTime				x			
	processType					x		
	resultNature							x
	onlineResource						x	
	featureOfInterest			x				
	observedProperty		x					
	procedure	x						

Figure 38: INSPIRE ObservingCapability- GetDataAvailability V2 reponse mapping

Annex F: Hierarchical Observation Offerings Specification (normative)

This section describes how to model the relation between an Observation Offering and the lower-level Offerings it contains within the ObservationOfferings section of SOS Capabilities document.

swes:extension element available the ObservationOfferings section for defining an additional element which contains information about the sub-offerings of a higher-level offering will be reused.

Since no XML schema exists at the OGC specification level to describe the offering/sub-offering relation in the swes:extension, a suitable extension element has been defined. This extension shall be named relatedOffering:

Element	Description	Cardinality
relatedOffering	Contains an OfferingContext element which describes an offering relation	0..*

Each relatedOffering element shall contain an OfferingContext element describing one relation between offering and sub-offering:

Element	Description	Cardinality
role	Role of the relation (gml:ReferenceType)	1..1
relatedOffering	Link to the related offering (gml:ReferenceType)	1..1

Finally, it is recommended to add an additional name attribute to the extension element of the Observation Offerings in order for the client to find the extension of interest if several extensions are contained in the object. The attribute should be of type NCName.

The figure below provides an overview of the relatedOffering schema.

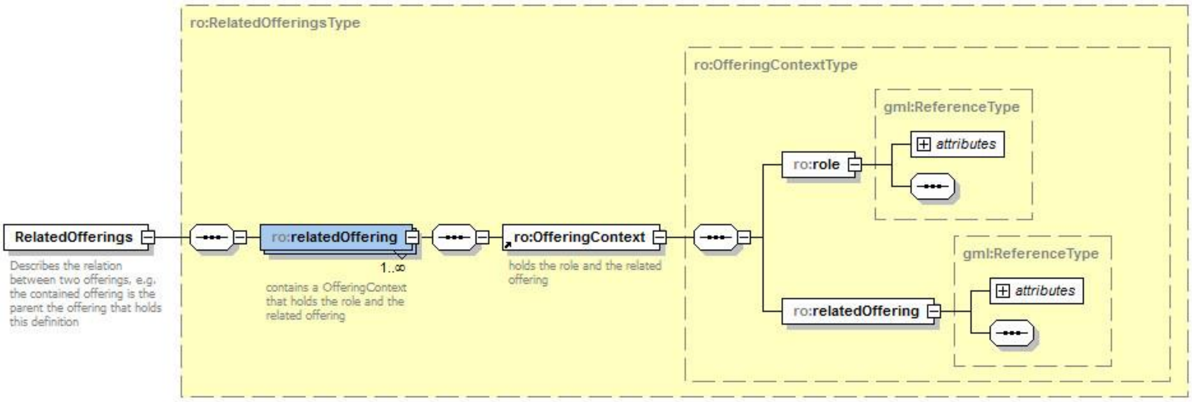


Figure 39: relatedOffering schema

The following listing shown as example of this approach (the “ro” namespace prefix is a placeholder for the final namespace and namespace prefix):

```
<sos:Capabilities version="2.0.0">
   <sos:ObservationOffering>
<swes:identifier>http://www.52north.org/test/offering/1</swes:identifier>
      <swes:name> codeSpace="eng">Offering for sensor 1</swes:name>
      <swes:extension name="relatedOfferings">
         <ro:RelatedOfferings>
            <ro:relatedOffering>
               <ro:OfferingContext>
                  <ro:role xlink:href="http://.../offering/child" />
                  <ro:relatedOffering xlink:href="http://...=GetDataAvailability
                                                &offering=http://www.52north
                                                .org/test/offering/1/1"
                                      xlink:title="http://www.52north.org
                                                 /test/offering/1/1"/>
               </ro:OfferingContext>
            </ro:relatedOffering>
            <ro:relatedOffering>
               <ro:OfferingContext>
                  <ro:role xlink:href="http://.../offering/child" />
                  <ro:relatedOffering xlink:href="http://...=GetDataAvailability
                                                &offering=http://www.52north.
                                                .org/test/offering/1/2"
                                      xlink:title="http://www.52north.org
                                                 /test/offering/1/2"/>
               </ro:OfferingContext>
            </ro:relatedOffering>
         </ro:RelatedOfferings>
      </swes:extension>
      <swes:procedure>
         http://www.52north.org/test/procedure/1
      </swes:procedure>
   </sos:ObservationOffering>
</sos:Capabilities>
```

Figure 40 : relatedOffering example

Annex G: Revision history (informative)

Date	Release	Author	Paragraph modified	Description
2011-06-12	1.0	Katharina Schleidt	All	Initial D2.9 release
2013-02-22	2.0rc3	Katharina Schleidt	All	Reflects the content of the draft amendment to Commission Regulation (EU) No 1089/2010 for the Annex II+III spatial data themes as submitted to the INSPIRE Committee.
2016-01-28	3.0Draft1	Sylvain Grellet	All	Complete restructuration of D2.9 to an OGC profile according Ispra meeting
2016-03-21	3.0Draft2	Sylvain Grellet	All	Generated after draft1 circulation to core group, feedback taken into account + link with TG SOS update exercise
2016-05-12	3.0Draft3	Sylvain Grellet	All	After JRC revision
2016-06-09	3.0Draft4 (publicly named rc1)	Sylvain Grellet	All	After Inspire maintenance group (MIWP-7a) feedbacks
2016-10-10	rc2	Sylvain Grellet	All	After Member States feedbacks (MIG-T)
2016-11-18	rc2	Alexander Kotsev and Michael Lutz	All	Editorial changes to harmonise the document with other TG documents

Annex H: Short introduction to O&M (informative)

H.1 Context

While INSPIRE is foremost a Spatial Data Infrastructure, several of the Annex II & III themes have been specified so that their scope, in addition to the basic spatial information, includes measured, modelled or simulated data about the real world. The ISO 19156:2011 International Standard on Observations and Measurements (O&M) was designed for this explicit purpose, and thus shall be used in INSPIRE to cover these requirements.
In order to maintain compatibility with the various domain specific standards based on O&M such as CSML or WaterML 2.0, INSPIRE Cross Thematic Working Group on Observations & Measurements has decided not to specialise OM_Observation with additional attributes within INSPIRE; all specialisations provided only pertain to the addition of constraints.

This section serves as a simple overview of the main concepts of the O&M standard for better understanding of the INSPIRE specific design patterns proposed. For more detailed information on O&M, please refer either to ISO 19156:2011 or the OGC Document: OGC 10-004r3 (Geographic Information: Observations and Measurements - OGC Abstract Specification Topic 20). Its Annex B provides a '*Mapping of O&M terminology to common usage*'.

H.2 Observations and Measurements

O&M is intended for cross-domain work and data exchange; it should mainly be used if provenance and quality of property values shall be provided with the data (e.g. to allow users to determine fitness-for-purpose).
It is also useful for data discovery using the primary slots in the model (feature of interest, observed property, procedure) and can assist in data fusion across discipline boundaries.
For intra-domain purposes, if the observation metadata is not important to the user, or the provider does not want to provide it, do not use O&M.
Before a decision is reached to use O&M, the requirements must be clearly analysed to determine if an Observation-centric view is necessary or if a Result/Coverage-centric view will suffice (see chapter "6.1.1 Use of O&M vs. Coverage Model").

H.3 Observations

For the structuring of data pertaining to observations, the O&M standard has defined the OM_Observation type. The following diagram shows the basic OM_Observation type with all its attributes, associations and constraints.

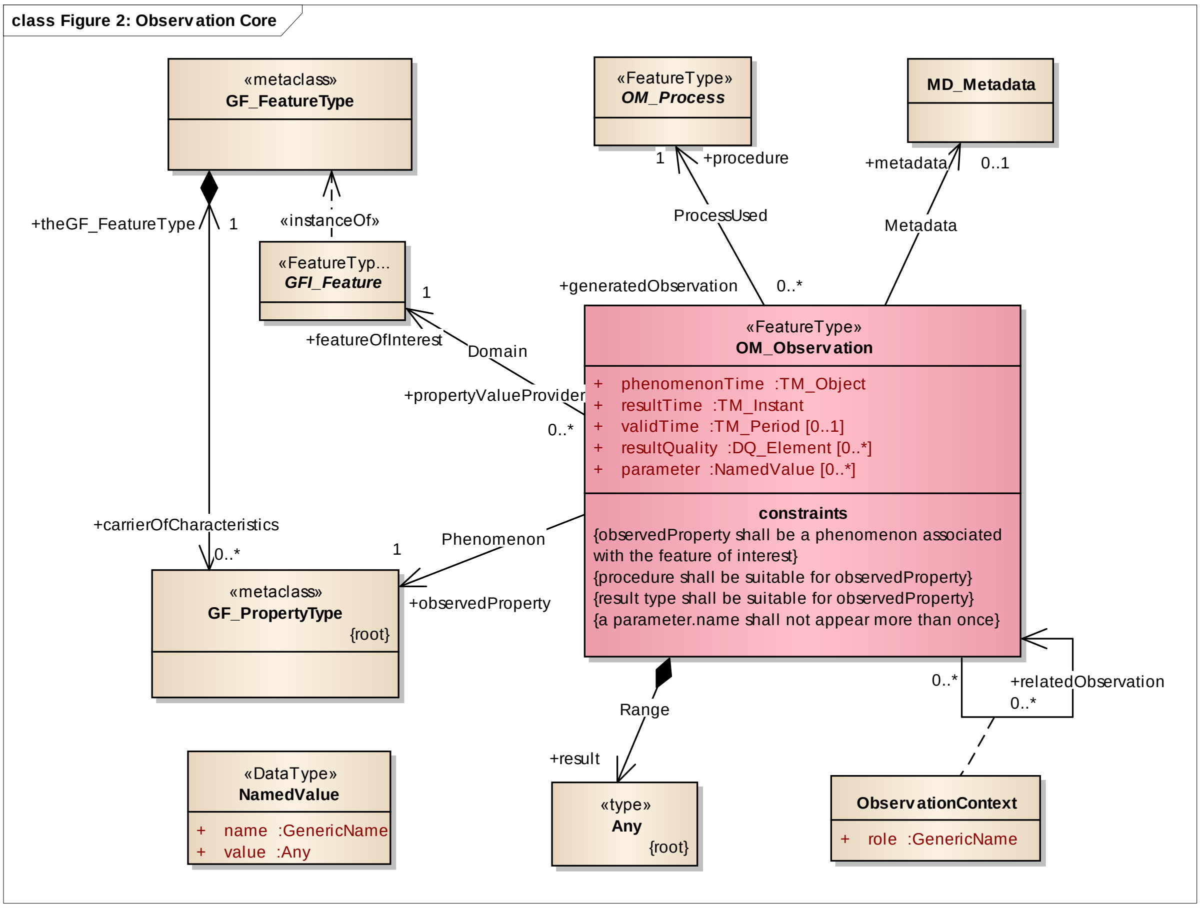


Figure 41: The basic Observation type

The UML diagram above could be read as follows: "An Observation is an action whose **result** is an estimate of the value of some **property** of the **feature-of-interest**, at a specific point in **time**, obtained using a specified **procedure**" (after Cox 2008).

H.3.1 *Observation Associations*

The following associations link classes to the observation that serve to explicitly describe all aspects of the observation performed,

H.3.1.1 Feature-Of-Interest

Association:	*Domain*
Role:	*featureOfInterest*
Inverse Role:	*propertyValueProvider*

The association Domain links to the FeatureType (*GFI_Feature)* that is the subject of the observation and carries the observed property. This is a representation of the real world object the property is being estimated on or is a feature intended to sample the real-world object

In the "O&M Design Patterns" chapter various example of featureOfInterest are introduced:

- species occurrence point
- air bubble surrounding intake
- water column
- trajectory
- grid
- water sample

Various terms are often used in other domains:

Earth Observations:	2-D swath or scene; 3-D sampling space
Earth science simulations:	Section, swath, volume, grid
Assay/Chemistry:	Sample
Geology field observations:	Location of structure observation; Rock sample

H.3.1.2 Property

The association Phenomenon links to the *GF_PropertyType* describing the property of the feature-of-interest that is being estimated in this observation.

In the "O&M Design Patterns" chapter, the following types are used as observedProperty:
- height
- O3 hourly mean
- salinity
- (water) temperature
- (water) color
- nitrate concentration
- biochemical oxygen demand

The following terms are used to refer to the property in other domains:

Earth Observations:	parameter, variable such as Reflectance, Particulate Matter 2.5
Metrology:	measurand such as Mass
Earth science simulations:	Variable, parameter
Assay/Chemistry:	Analyte
Geology field observations:	Strike and dip, lithology, alteration state, etc.

H.3.1.3 Procedure

Association: *ProcessUsed*
Role: *procedure*
Inverse Role: *generatedObservation*

The association ProcessUsed links to the *OM_Process* describing the process or methodology used in the estimation of the result in this observation.

In the "O&M Design Patterns" chapter, the following types are used as observedProperty:
- Triagulation
- EquipmentType : Horiba APNA (360), detection limit 0.1
- Survey Ship Type X, Probe Type Y, Thermometer Type Z, Camera Type A, Lens Type B, Simulation algorithm xx
- Laboratory X, Method Y

The following terms are used to refer to the procedure in other domains:

Earth Observations:	method, sensor type such as ASTER
Metrology:	instrument such as a balance
Earth science simulations:	Earth process simulator
Assay/Chemistry:	Instrument, analytical process

H.3.1.4 Result

Association: *Range*
Role: *result*

The association Range links to the estimate of the property on the feature-of-interest generated by the procedure.

The following terms are used to refer to the Result in other domains:

Earth Observations:	observation value, measurement value, observation such as 35 µg/m
Metrology:	Value such as 35 mg
Earth science simulations:	model
Assay/Chemistry:	Analysis

H.3.2 *Observation Attributes*

The following attributes provide further detail on the observation performed.

H.3.2.1 Parameter

Datatype: *NamedValue*

The attributes provided under parameter describe any event-specific parameter of relevance to interpreting the observation. These will typically complement the re-usable (event-neutral) description of the observation procedure. The datatype *NamedValue* allows for the provision of key/value pairs for the parameter.

Within O&M, any GenericName may be provided as the name, and any data type may be provided for the value. In this document, this attribute as been already used for specific purposes:
- See chapter 7.1.4 Procedure esp 'processParameter' requirements
- or chapter 7.1.5 Online resource.

H.3.2.2 PhenomenonTime

Datatype: *TM_Object*

The attribute phenomenonTime shall describe the time that the result applies to the property of the feature-of-interest.
[ISO 19156:2011(E)]

This may be the time when a specimen was collected or the observation procedure was performed on a real-world feature, but may be in the future in the case of forecasts, or in the deep past for archeological or geological observations. The type '*TM_Object'* allows for time instants, time periods (where the result is extensive in time such as a temporal coverage), or temporal topologies if this is the most appropriate representation.

H.3.2.3 ResultQuality

Datatype: *DQ_Element*

When the Observation result consists of a single value, or a set of values that are all of the same quality, the quality of the result is to be provided here.
However, in the case of complex results (spatial or temporal coverages), the quality may vary across the result values; in this case, the quality should be provided for each value within the result.

A third option not to trigger the machinery of ISO 19157 in simple usecases is to store quality related information in the 'Parameter' attribute.

H.3.2.4 ResultTime

Datatype: *TM_Instant*

The attribute resultTime describes the time when the result became available, typically when the procedure associated with the observation was completed. For some observations this is identical to the phenomenonTime. However, there are important cases where they differ.
[ISO 19156:2011(E)]

An example of this is a specimen analyzed in a laboratory, where the PhenomenonTime should correspond to the time the specimen was taken, while the ResultTime is the time when the laboratory analysis was completed.

H.3.2.5 ValidTime

Datatype: *TM_Period*

If present, the attribute validTime describes the time period during which the result is intended to be used. This attribute is commonly required in forecasting applications.
[ISO 19156:2011(E)]

H.4 featureOfInterest and Sampling / SampledFeature identification

H.4.1 *Introduction*

In order to understand the meaning of an observation, one must also understand the exact domain of the observation, the feature-of-interest. In some cases, this feature-of-interest can be analysed in its entirety. Some examples for this are:
- The weight of a specific animal
- The type of crop planted on a specific field

In this case, this domain feature should be directly used as the '*featureOfInterest'* of the Observation. In other cases, it is difficult to estimate a property on the entirety of a feature; thus, one usually samples one representative part of this larger feature for analysis purposes. In this case, the feature-of-interest is an artefact of the sampling strategy which in O&M is called the '*samplingFeatur'e*, which refers to the feature it has been taken as a representative of as its '*sampledFeature'*. Some examples of this are:
- A rock sample taken as a representative for an outcrop.
- The measurement of air temperature at a particular location (sampling the atmosphere at a point).
- A sample of river water taken as a representative for the river segment sampled from.

The diagram below shows the relation between SamplingFeature and SampledFeature:

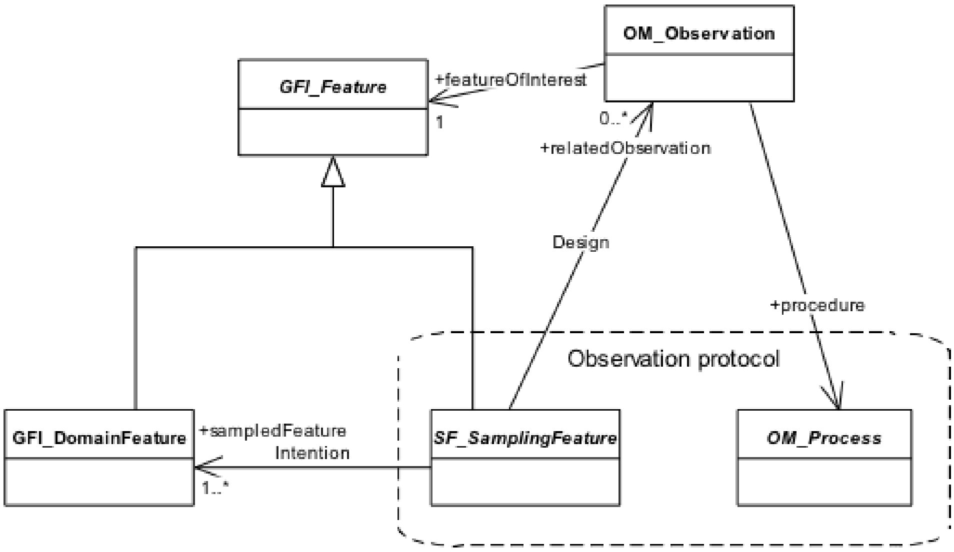


Figure 42: Sampling feature vs. sampled feature [ISO 19156:2011, figure 10]

In further cases, a specific specimen is taken and analysed; for this purpose, *SF_Specimen* has been defined as a specialised form of SF_SamplingFeature.

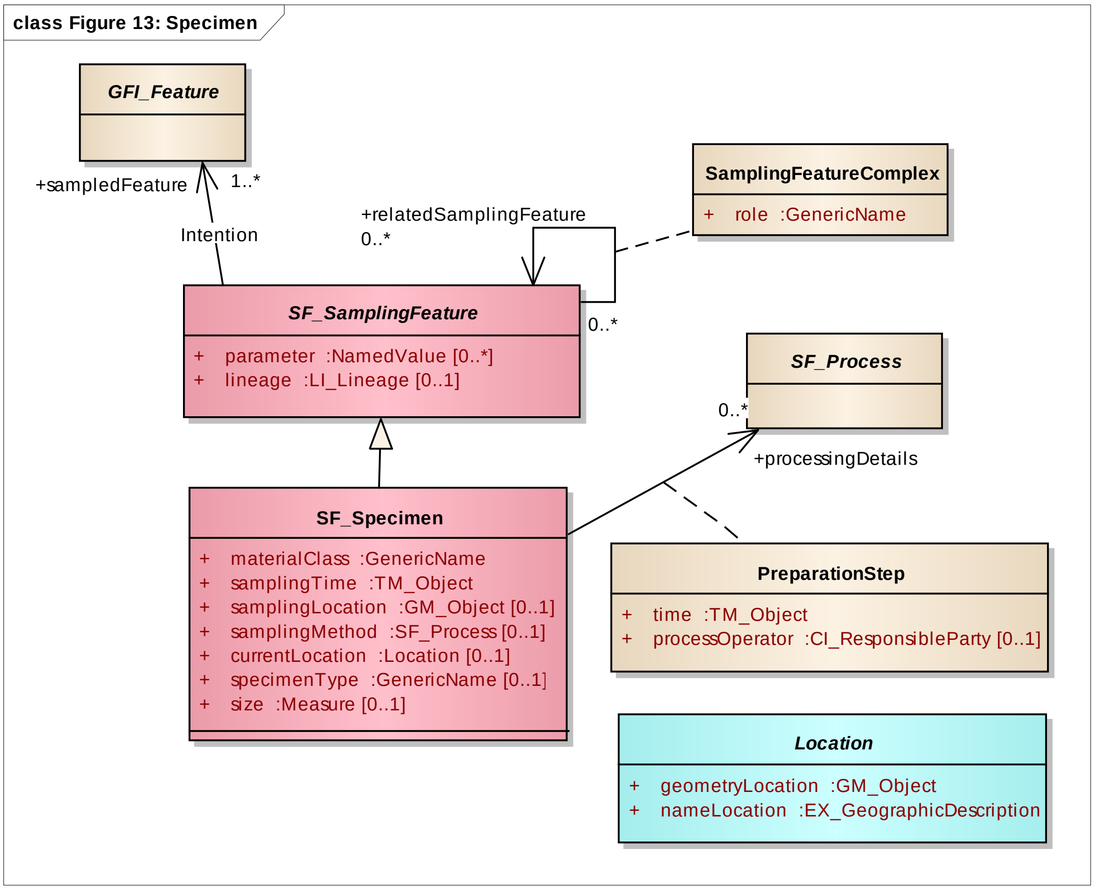


Figure 43: SF_Specimen overview

H.4.2 *SamplingFeature*

A samplingFeature is an intermediate feature involved in an observation which allows an estimate of a property value for the ultimate feature of interest to be made; this feature provides the direct context for the specific observation (spatial, specimen). In the case of a spatial sampling feature, which is derived from the *SF_SamplingFeature*, the spatialSamplingFeature is a point, line, surface or volume which may be co-located with the ultimate FOI. e.g. a point in a river. The result values will vary across the spatialSamplingFeature.

The following terms describe specific samplingFeatures in various domains:

Earth Observations:	2-D swath or scene; 3-D sampling space
Earth science simulations:	Section, swath, volume, grid
Assay/Chemistry:	Polished section, probe spot, pulp
Geology field observations:	Outcrop; Location of structure observation

H.4.3 *Sampled Feature*

The sampledFeature is the feature the samplingFeature was sampled from, providing the ultimate context for the observation. An example of sampledFeature would be the river segment a specimen was taken from

The following terms are used to refer to the sampledFeature in other domains:

Earth Observations:	Earth surface; media (air, water, …), Global Change Master Directory "Topic"
Earth science simulations:	Atmosphere, ocean, solid earth
Geology field observations:	Ore body, Geologic Unit

H.4.4 *Specimen*

A specimen is a feature sampled from a feature of interest to enable ex-situ observation, such as in a laboratory. Information on how the specimen was acquired, where it is presently stored, and its preparation procedure are provided.

The following terms are used to refer to the Specimen in other domains:

Assay/Chemistry:	Sample; Pulp, separation
Geology field observations:	Rock sample

H.5 Sampling Features in SamplingCoverageObservations

Most of the specialised observations described in ": INSPIRE specialised observations" are derived from the specialized Observation class called SamplingCoverageObservation, which is defined in Annex D of ISO 19156:2011.

One of the constraints imposed on the SamplingCoverageObservation is that the featureOfInterest must be a SamplingFeature.

A further constraint imposed by use of the SamplingCoverageObservation is that the shape of the sampling feature of interest shall contain the spatial elements of the domain of the coverage result. The intention behind this constraint is explained in detail in Woolf, A. (ed.): *Climate Science Modelling Language (CSML): Sampling Coverage Observations for the met/ocean domain* (OGC 11-021):

> "(A) spatial sampling feature may provide a summary description of a sampling geometry more fully specified in the result of a discrete coverage observation. In this sense it may be regarded as playing a role similar to the familiar 'bounding box' of dataset metadata (aiding discovery and spatial querying), but with a richer choice of geometries more suitable for observations. (…)
>
> The shape of the spatial sampling feature may be regarded as a projection of the full spatiotemporal sampling geometry onto a spatial subspace . Projection of the full sampling geometry onto the temporal axis defines the time of the observation. Thus, the spatial sampling feature and observation phenomenon time broadly summarise the 'where' and 'when', respectively, of an observation, with the full geometric sampling complexity available in the domain of the coverage result."

Thus, special care must be taken when defining SamplingFeatures for the use with SamplingCoverageObservations, to make sure that the domain of the result coverage is inside the geometry of the SamplingFeature.

Example:
A SamplingFeature in the water domain is modelled as the grid used as the domain in the resulting coverage; this grid is defined covering the entirety of a specific lake. The SamplingFeature points to this specific lake as SampledFeature; the lake can in turn be sampled from the Terrestrial Hydrosphere.

H.6 Process

Within O&M, the base definition of *OM_Process* is an empty class. For use within INSPIRE, the following 2 options have been determined:

- Process: The Process class defined within INSPIRE allows for the lightweight provision of procedural information. The disadvantage is that it goes away from the base standard and thus must be optional to allow for re-use of domain standards
- SensorML: A SensorML overview is provided in "Annex I : Short introduction to SWE", chapter "*I.3* SensorML Overview*"*. Using SensorML has the advantage of maintaining compliance with the wider SWE scope. To bring this closer to INSPIRE, we propose a standardized mapping of agreed upon attributes to the SensorML model (see "Annex C : INSPIRE Process", chapter "*C.2 Process Encoding with SensorML 1.0.1"*). It is important to keep in mind that SensorML was developed by a team whose main experience was remote sensing, so it may not be suitable for all domains. Much will depend on how SensorML V2.0 is taken into account in SOS revision.

H.6.1 *Types of Process Parameters expected*

Very different types of information will be supplied via the Process Parameters. At present, the following categories have been identified:

- Results of related "observations": not necessarily available in the form of an observation, the information provided are the results of related observations relevant to the current observation. Examples of this are:
  - the water hardness of the river being sampled from
  - the width of the river at the measurement point
- Temporal information not currently covered by the OM_Observation. This is often necessary in forecasts and modeling. Examples of this are:
  - Analysis Time
  - Forecast period
- Instrument settings can be stored via process parameters to allow for the reuse of this process instance in various settings. Examples of this are:

   - sampling rate
   - minimum & maximum offset
- EnsembleMember can be specified as an easy way of providing data from aggregate sensors. In this case, the Process Parameters provide information in which exact sensor was used.

H.6.2 *Referencing Process Parameters*

For true interoperability, the re-use of Process Parameters stemming from an external source (vocabulary) is necessary.

H.7 Result

In many cases, it will be possible to provide the result data using either GML coverages or the result types provided in SWE Common. These allow for the standardized encoding of a wide range of simple and complex result types including spatial and temporal coverages.

The following examples from ISO 19156:2011 illustrate different types of observations with various types of spatial sampling features. They are listed in order to provide help in understanding the different types of results that would be consistent with the spatial sampling feature type in these observations:

Observation class	Example	Spatial sampling feature	Coverage result
Profile	Expendable bathythermograph observation of seawater temperature	SF_SamplingCurve	• one-dimensional grid at fixed (x,y,t) within four-dimensional (x-y-z-t) CRS • grid axis aligned with CRS z-axis
ProfileTimeSeries	Radar wind profiler measurement	SF_SamplingCurve	• two-dimensional grid at fixed (x,y) within four-dimensional (x,y,z,t) CRS • grid axes aligned with CRS z- and t-axes
Trajectory	Pollutant concentration from mobile air quality sensor	SF_SamplingCurve	• one-dimensional grid within four-dimensional (x-y-z-t) CRS
Section	Vertical profiles of water current measurements taken by an acoustic doppler current profiler towed along a ship's track	SF_SamplingSurface	• two-dimensional grid within four-dimensional (x-y-z-t) CRS • one grid axis aligned with CRS z-axis
GridTimeSeries	Time-series of 3-D velocity field from a finite-difference seismic model	SF_SamplingSolid	• four-dimensional grid within four-dimensional (x-y-z-t) CRS

Figure 44 : Examples of coverage results for different sampling regimes [ISO 19156:2011, Table D.1]

H.8 Facility / Network

While there is no formal facility or station concept within the O&M standard, there is often a requirement to provide information on specialized locations used for the provision of multiple observations. While the O&M standard suggests the modelling of stations, which could be seen as facilities, as a form of SamplingPoint, this causes difficulties when one wishes to include remote sensing within the facility concept. It also doesn't provide support for mobile facilities, and thus cannot be used within the INSPIRE context.

Within INSPIRE, Environmental Monitoring Facilities are their own theme across thematic domains. At the same time, other INSPIRE Themes provide either primary data from Environmental Monitoring Facilities, or processes results based on this primary data.
Thus, an '*EnvironmentalMonitopringFacility*' concept is being defined to cover the requirements stemming from all these themes. INSPIRE 'Environmental Monitoring Facilities' can also be grouped together into Environmental Monitoring Networks. For further details please refer to INSPIRE "D2.8.III.7 Data Specification on Environmental Monitoring Facilities – Technical Guidelines".

As derived coverage results are often calculated from primary measurements stemming from an entire network, this type of observation should be linked to the Network class.

Annex I: Short introduction to SWE (informative)

I.1 Context

In addition to the use of the Observations and Measurements standard, further elements of the OGC Sensor Web Enablement Suite (SWE) have been identified as useful for the encoding and provision of observational data. While further SWE specifications may be nominated for use in INSPIRE, at the present we have identified the following:

- Sensor Observation Service (SOS): service created for the provision of observational data;
- SensorML: Standard for the provision of procedural information;
- SWE Common: Includes result encoding options.

Please note, that there are more SWE elements and services respectively. However, they are not within the scope of this document. Please see *http://www.opengeospatial.org/ogc/markets-technologies/swe* for a wider view on this topic including sensor tasking, filtering, notifications from sensor measurements, etc.

I.2 SOS Overview

The OGC SOS specification is based on the OGC Web Service Common specification, thus, it has shared structures and data types of service requests with the other OGC Web Services. In the case of SOS, the operation signature is constrained by the observation schema, as it defines the response model.
Overview of core operation is provided below, for more detailed information on SOS version 2.0, please refer to the OGC Document provided in chapter '3.References'.

I.2.1 *GetCapabilities*

This operation allows clients to retrieve service metadata about a specific service instance, including metadata about the tightly-coupled data served. In addition to more generic capabilities response elements such as filter options, the SOS GetCapabilities returns a list of so called '*ObservationOffering*', which are groupings of available observations described by their feature of interest, procedure, observed property, temporal coverage and the like. This allows the user application to clearly identify the types and quality of data that can be requested from this service.

I.2.2 *GetObservation*

The GetObservation operation is designed to query a service to retrieve observation data structured according to the Observations and Measurements specification. Within the GetObservation request, the user can provide a filter, including the desired observed property, feature of interest, time interval, observationoffering identifier which determines which observations are to be returned. The response to the GetObservation request is one or more observations encoded as an *OM_Observation*, as shown in ": Short introduction to O&M".

I.2.3 *DescribeSensor*

DescribeSensor is designed to request detailed sensor metadata. The response of this operation provides this procedural metadata, encoded using a well-defined format. This provides all information required on how the observation or measurement was obtained. This information should be sufficient to determine if the data from the observations meets ones further processing requirements.

I.2.4 *GetFeatureOfInterest*

GetFeatureOfInterest returns a feature of interest that is associated with an observation served by the SOS. The features are encoded using a specific GML application schema.

I.3 SensorML Overview

Sensor Model Language (SensorML) was created by the sensor community for structuring of information pertaining to sensors. This covers all procedural information as required within O&M, and is often the default procedure format expected by SOS implementations as this is the primary recommendation from SOS 2.0. Of primary interest to these guidelines is the SensorML component class – this class was created for the description of measurement components (i.e. individual sensors). For complex properties the system class may be used,

While SensorML was primarily designed by the sensor community, due to its abstract structure it can also be used for data survey process descriptions not using sensors, or very abstract concepts of sensors such as human sensors performing a biodiversity survey.

At present, SensorML is available in versions 1.0.1. and 2.0. SensorML version currently being identified by Sensor Observation Service (SOS) 2.0 (OGC 12-006) is version 1.0.1.
Thus, only that version has been considered within this document.
A mapping between the INSPIRE Process Feature Type and SensorML 1.0.1 is provided in section C.2.1 “Mapping to SensorML”.

For more detailed information on SensorML, please refer to the OGC Document: OGC® 07-122r2.

I.4 SWE Common Result Encoding

OGC SWE 2.0 provides dedicated result types in the package SWE Common. For an example of the encoding of time series data (in the example given it pertains to air quality measurements), please see “Annex L : Examples”, chapter “L.2 SWE Common Results”.

Annex J: Observable properties model (informative)

This exercise is based on the experience from Climate Science Modelling Language version 3 (OGC Pending Docs 11_021) which extends ISO 19156.

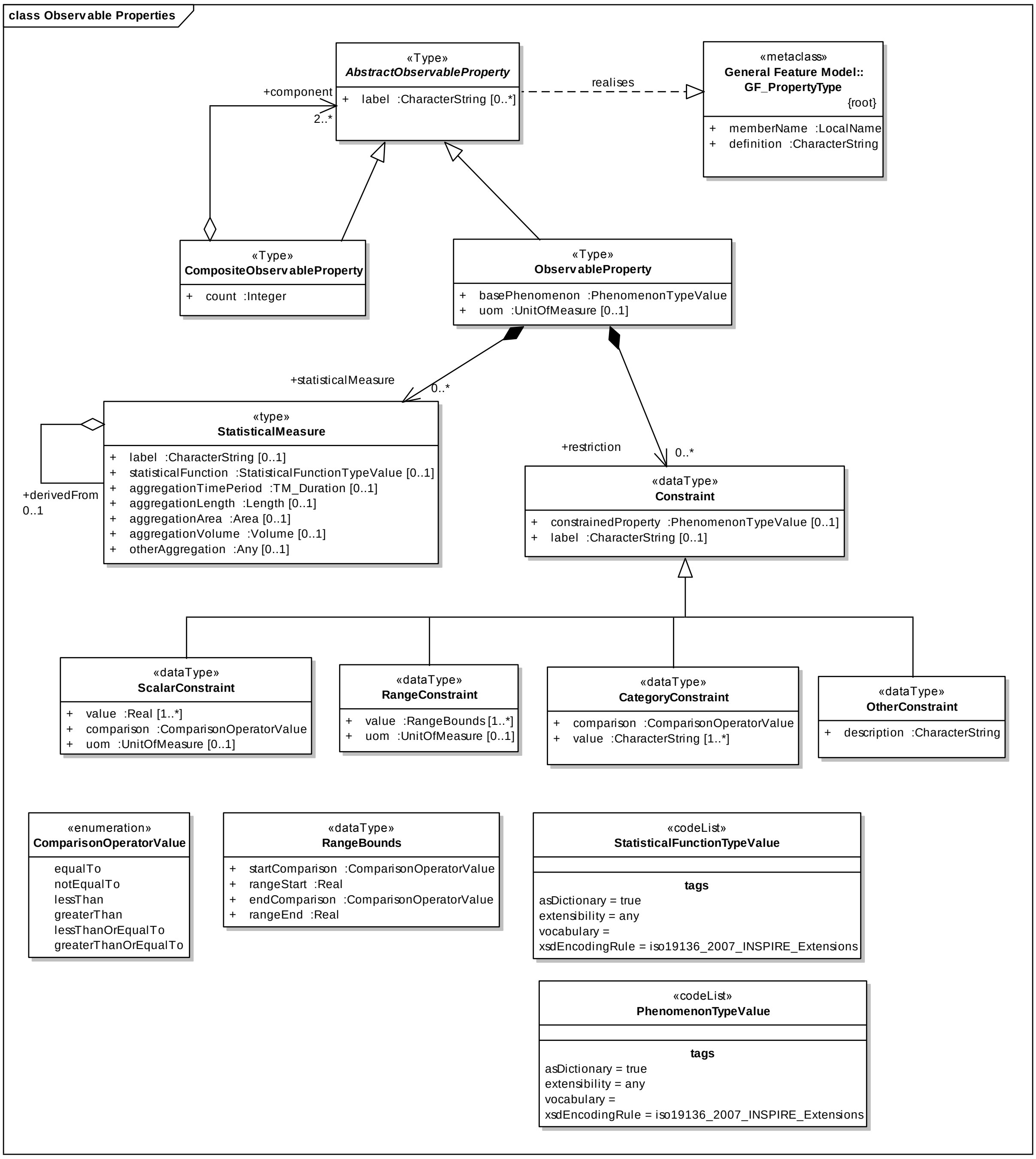


Figure 45 : Complex Properties Model

J.1 AbstractObservableProperty

The AbstractObservableProperty class is the root of the ObservableProperty model. It is implemented by two specialisations: ObservableProperty and CompositeObservableProperty.

J.2 ObservableProperty

At its simplest an ObservableProperty simply carries a reference to a phenomenon definition in a codelist with optional units of measure. However an ObservableProperty definition may be augmented using Constraints and/or Statistical Measures to create a more full definition of the observed property.

J.3 Statistical Measures

The StatisticalMeasure is used to describe some statistical grouping of the data. It has an attribute where one can provide the statistical function being applied (i.e. mean). In addition, it provides attributes for the description of what the statistics are being applied to, i.e over what dimension the mean is being taken over.

For the provision of hourly means, one would enter a reference to "mean" in the statisticalFunction attribute and then provide a duration of an hour in the aggregationTimePeriod attribute. StatisticalMeasures can be aggregated over time, spatial dimensions or any other defined aggregation type. An example of a spatial aggregation would be 'maximum per km^2'.

Note that a StatisticalMeasure may be derived from another StatisticalMeasure. For example Mean Monthly Maximum Temperature derived from Mean Daily Maximum Temperature.

J.4 Constraints

In order to provide other constraints on ObservableProperties, the type Constraint has been created and can be associated with an ObservableProperty. Constraint types have been provided for scalar, range and category constraints, as well as a generic OtherConstraint data type. The following list provides examples for the constraint types defined:

- Scalar Constraint: A numerical scalar constraint on some property e.g. length >= 1m
- Range Constraint: A numerical range constraint on some property e.g. wavelength >=300nm and wavelength <=600nm. To be used when data is observed in particular bands or groupings based on a numerical quantity.
- Category Constraint: A constraint based on some qualifying category. e.g. colour = 'Red'. The value ('Red') of the constraint ('colour') can be any string, although it may be desirable to constrain this in particular application domains.
- Other Constraint: Any other constraint type not easily expressed using the other Constraint types.This type may be specialised or the simple description attribute may be used to provide a free text description of the constraint.

9.1.1 CompositeObservableProperty

Usually, when performing multiple observations on one featureOfInterest, one provides a separate ObservableProperty element for each Phenomenon being observed. However, in certain cases where either a) there is a strong link between the Phenomena or b) the multiple phenomena are clearly observed as part of the same Observation, these Phenomena may be provided together in one Observation. In this case a CompositeObservableProperty can be defined that groups together multiple Phenomena (ObservableProperty) into one CompositeObservableProperty element.

An example of a strongly linked pair of Phenomena is wind speed and wind direction.

J.5 Feature catalogue

Feature catalogue metadata

Application Schema	INSPIRE Application Schema Observable Properties
Version number	2.0

Types defined in the feature catalogue

Type	Package	Stereotypes
CategoryConstraint	Observable Properties	«dataType»
Constraint	Observable Properties	«dataType»
OtherConstraint	Observable Properties	«dataType»
RangeBounds	Observable Properties	«dataType»
RangeConstraint	Observable Properties	«dataType»
ScalarConstraint	Observable Properties	«dataType»

J.5.1 *Data types*

J.5.1.1 CategoryConstraint

CategoryConstraint

Name:	Category Constraint
Subtype of:	Constraint
Definition:	A constraint based on some qualifying category. e..g colour = 'Red'.
Description:	A constraint based on some qualifying category. e..g colour = 'Red'. The value ('Red') of the constraint ('colour') can be any string, although it may be desirable to constrain this in particular application domains.
Stereotypes:	«dataType»

Attribute: comparison

Name:	comparison
Value type:	ComparisonOperatorValue
Definition:	A comparison operator. In the case of a category constraint it should be 'equalTo' or 'notEqualTo'.
Multiplicity:	1

Attribute: value

Name:	value
Value type:	CharacterString
Definition:	The value of the property that is constrained e.g. 'blue' (if the constrained property is colour)
Multiplicity:	1..*

J.5.1.2 Constraint

Constraint

Name:	Constraint
Definition:	A constraint on some property e.g. wavelength = 200nm.
Description:	A constraint on some property e.g. wavelength = 200nm. This property is typically not the same property as the base phenomenon of the observed property. e.g. the observed property has a base phenomenon 'radiance'. a constraint is added to say 'wavelength = 200nm' So the overall ObservableProperty which is represented is 'radiance where wavelength = 200nm' The Constraint class is specialised into several specific classes covering Scalar, Range and Categorical constraints
Stereotypes:	«dataType»

Constraint

Attribute: constrainedProperty

Name:	constrainedProperty
Value type:	PhenomenonTypeValue
Definition:	The property being constrained. e.g. 'colour' if the constraint is 'colour = blue'
Multiplicity:	0..1

Attribute: label

Name:	description
Value type:	CharacterString
Definition:	A human readable title for the constraint as a whole
Multiplicity:	0..1

J.5.1.3 OtherConstraint

OtherConstraint

Name:	Other Constraint
Subtype of:	Constraint
Definition:	A constraint, not modelled in a structured way, but may be described using the freetext 'description' attribute.
Stereotypes:	«dataType»

Attribute: description

Name:	description
Value type:	CharacterString
Definition:	A description of the constraint.
Multiplicity:	1

J.5.1.4 RangeBounds

RangeBounds

Name:	Range Bounds
Definition:	The start and end bounding values of a numerical range (e.g. start >=50, end <=99)
Stereotypes:	«dataType»

Attribute: startComparison

Name:	startComparison
Value type:	ComparisonOperatorValue
Definition:	The comparator used for the lower range limit (e.g. greaterThanOrEqualTo)
Multiplicity:	1

Attribute: rangeStart

Name:	rangeStart
Value type:	Real
Definition:	The lower limit of the range.
Multiplicity:	1

Attribute: endComparison

Name:	endComparison
Value type:	ComparisonOperatorValue
Definition:	The comparator used for the upper range limit (e.g. lessThan)
Multiplicity:	1

Attribute: rangeEnd

RangeBounds

Name:	rangeEnd
Value type:	Real
Definition:	The upper limit of the range.
Multiplicity:	1

J.5.1.5 RangeConstraint

RangeConstraint

Name:	Range Constraint
Subtype of:	Constraint
Definition:	A numerical range constraint on some property e.g. wavelength >=300nm and wavelength <=600nm
Description:	A numerical range constraint on some property e.g. wavelength >=300nm and wavelength <=600nm e.g. To be used when data is observed in particular bands or groupings based on a numerical quantity.
Stereotypes:	«dataType»

Attribute: value

Name:	value
Value type:	RangeBounds
Definition:	The numerical value range of the property that is constrained
Multiplicity:	1..*

Attribute: uom

Name:	uom
Value type:	UnitOfMeasure
Definition:	Units of measure used in the constraint
Multiplicity:	0..1

J.5.1.6 ScalarConstraint

ScalarConstraint

Name:	Scalar Constraint
Subtype of:	Constraint
Definition:	A numerical scalar constraint on some property e.g. length >= 1m
Description:	A scalar constraint on some property e.g. length >= 1m
Stereotypes:	«dataType»

Attribute: value

Name:	value
Value type:	Real
Definition:	The numerical value of the property that is constrained
Multiplicity:	1..*

Attribute: comparison

Name:	comparison
Value type:	ComparisonOperatorValue
Definition:	The comparator to be used in the constraint e.g. greaterThan
Multiplicity:	1

Attribute: uom

Name:	uom
Value type:	UnitOfMeasure
Definition:	Units of measure used in the constraint

ScalarConstraint	
Multiplicity:	0..1

J.5.1.7 StatisticalMeasure

StatisticalMeasure	
Name:	Statistical Measure
Definition:	A descripton of some statistical measure e.g. "daily maximum"
Description:	A descripton of some statistical measure e.g. "daily maximum" The measure is usually some function over some time (e.g. an hour, a day) or space (e.g. a length, area or volume) Other aggregation types can be supported via the 'otherAggregation' extension point.
Stereotypes:	«type»
Attribute: label	
Name:	label
Value type:	CharacterString
Definition:	A human readable title for the statistical measure
Multiplicity:	0..1
Attribute: statisticalFunction	
Name:	statisticalFunction
Value type:	StatisticalFunctionTypeValue
Definition:	A statistical function e.g. (mean)
Multiplicity:	0..1
Attribute: aggregationTimePeriod	
Name:	aggregationTimePeriod
Value type:	TM_Duration
Definition:	A temporal range over which a statistic is calculated. e.g. A day, An hour.
Multiplicity:	0..1
Attribute: aggregationLength	
Name:	aggregationLength
Value type:	Length
Definition:	A one dimensional spatial range over which a statistic is calculated for example 1 metre.
Multiplicity:	0..1
Attribute: aggregationArea	
Name:	aggregationArea
Value type:	Area
Definition:	A two dimensional spatial range over which a statistic is calculated for example 1 square metre
Multiplicity:	0..1
Attribute: aggregationVolume	
Name:	aggregationVolume
Value type:	Volume
Definition:	A three dimensional spatial range over which a statistic is calculated for example 1 cubic metre
Multiplicity:	0..1
Attribute: otherAggregation	

StatisticalMeasure

Name:	otherAggregation
Value type:	Any
Definition:	Any other type of aggregation.
Multiplicity:	0..1

Association role: derivedFrom

Name:	derived from
Value type:	StatisticalMeasure
Definition:	One statistical measure may be derived from another. e.g. Monthly Maximum temperatures may be derived from Daily Mean temperatures.
Multiplicity:	0..1

J.5.2 *Enumerations*

J.5.2.1 ComparisonOperatorValue

ComparisonOperatorValue

Name:	ComparisonOperatorValue
Definition:	An enumeration of comparison operators (e.g. greater than)
URI:	

Value: equalTo

Definition: Exactly equal to

Value: notEqualTo

Definition: Not exactly equal to

Value: lessThan

Definition: Less than

Value: greaterThan

Definition: Greater Than

Value: lessThanOrEqualTo

Definition: Less than or exactly equal to

Value: greaterThanOrEqualTo

Definition: Greater than or exactly equal to

J.5.3 *Code lists*

J.5.3.1 PhenomenonTypeValue

PhenomenonTypeValue

Name:	Phenomenon Type Value
Definition:	A code list of phenomena (e.g. temperature, wind speed)
Description:	A code list of phenomena. This code list itself is an empty placeholder and should be extended and specified for any thematic domain.
Extensibility:	open
Identifier:	
Values:	The allowed values for this code list comprise the values of the following code lists and additional values at any level defined by data providers: • CFStandardNamesValue (INSPIRE Generic Conceptual Model, version 3.4 [DS-D2.5])

PhenomenonTypeValue
• ProfileElementParameterNameValue (INSPIRE Data specification on Soil [DS-D2.8.III.3]) • SoilDerivedObjectParameterNameValue (INSPIRE Data specification on Soil [DS-D2.8.III.3]) • SoilProfileParameterNameValue (INSPIRE Data specification on Soil [DS-D2.8.III.3]) • SoilSiteParameterNameValue (INSPIRE Data specification on Soil [DS-D2.8.III.3]) • EU_AirQualityReferenceComponentValue (INSPIRE Data specification on Atmospheric Conditions and Meteorological Geographical Features [DS-D2.8.III.13-14]) • BODC_P01ParameterUsageValue (INSPIRE Data specification on Oceanographic Geographical Features [DS-D2.8.III.15])

J.5.3.2 StatisticalFunctionTypeValue

StatisticalFunctionTypeValue	
Name:	Statistical Function Type Value
Definition:	A code list of statistical functions (e.g. maximum, minimum, mean)
Description:	A code list of statistical functions. This code list itself is an empty placeholder and should be extended and specified for any thematic domain.
Extensibility:	any
Identifier:	
Values:	The allowed values for this code list comprise any values defined by data providers.

J.5.4 *Imported types (informative)*

This section lists definitions for feature types, data types, enumerations and code lists that are defined in other application schemas. The section is purely informative and should help the reader understand the feature catalogue presented in the previous sections. For the normative documentation of these types, see the given references.

J.5.4.1 Any

Any	
Package:	Records and Class Metadata
Reference:	Geographic information -- Conceptual schema language [ISO/TS 19103:2005]

J.5.4.2 Area

Area	
Package:	Units of Measure
Reference:	Geographic information -- Conceptual schema language [ISO/TS 19103:2005]

J.5.4.3 BODC_P01ParameterUsageValue

BODC_P01ParameterUsageValue	
Package:	Oceanographic Geographical Features
Reference:	INSPIRE Data specification on Oceanographic Geographical Features [DS-D2.8.III.15]
Definition:	Definitions of phenomena observed in oceanography.

J.5.4.4 CFStandardNamesValue

CFStandardNamesValue	
Package:	NOT FOUND CFStandardNamesValue

J.5.4.5 CharacterString

CharacterString	
Package:	Text
Reference:	Geographic information -- Conceptual schema language [ISO/TS 19103:2005]

J.5.4.6 EU_AirQualityReferenceComponentValue

EU_AirQualityReferenceComponentValue	
Package:	Atmospheric Conditions and Meteorological Geographical Features
Reference:	INSPIRE Data specification on Atmospheric Conditions and Meteorological Geographical Features [DS-D2.8.III.13-14]
Definition:	Definitions of phenomena regarding air quality in the context of reporting under Union legislation.

J.5.4.7 Length

Length	
Package:	Units of Measure
Reference:	Geographic information -- Conceptual schema language [ISO/TS 19103:2005]

J.5.4.8 ProfileElementParameterNameValue

ProfileElementParameterNameValue	
Package:	Soil
Reference:	INSPIRE Data specification on Soil [DS-D2.8.III.3]
Definition:	list of properties that can be observed to characterize the profile element. The allowed values for this code list comprise a number of pre-defined values and narrower values defined by data providers. This code list is hierarchical.
Description:	Basically these parameters can be divided in several major groups like: • Chemical parameters • Physical parameters • Biological parameters

J.5.4.9 Real

Real	
Package:	Numerics
Reference:	Geographic information -- Conceptual schema language [ISO/TS 19103:2005]

J.5.4.10 SoilDerivedObjectParameterNameValue

SoilDerivedObjectParameterNameValue	
Package:	Soil
Reference:	INSPIRE Data specification on Soil [DS-D2.8.III.3]
Definition:	list of soil related properties that can be derived from soil and other data. The allowed values for this code list comprise a number of pre-defined values and narrower values defined by data providers. This code list is hierarchical.
Description:	Basically these parameters can be divided in several major groups like: • Chemical parameters • Physical parameters • Biological parameters

J.5.4.11 SoilProfileParameterNameValue

SoilProfileParameterNameValue	
Package:	Soil
Reference:	INSPIRE Data specification on Soil [DS-D2.8.III.3]
Definition:	list of properties that can be observed to characterize the soil profile. The allowed values for this code list comprise a number of pre-defined values and narrower values defined by data providers. This code list is hierarchical.
Description:	Basically these parameters can be divided in several major groups like: • Chemical parameters • Physical parameters • Biological parameters

J.5.4.12 SoilSiteParameterNameValue

SoilSiteParameterNameValue	
Package:	Soil
Reference:	INSPIRE Data specification on Soil [DS-D2.8.III.3]
Definition:	List of properties that can be observed to characterize the soil site. The allowed values for this code list comprise a number of pre-defined values and narrower values defined by data providers.
Description:	Basically these parameters can be divided in several major groups like: • Chemical parameters • Physical parameters • Biological parameters

J.5.4.13 TM_Duration

TM_Duration	
Package:	Temporal Objects
Reference:	Geographic information -- Temporal schema [ISO 19108:2002/Cor 1:2006]

J.5.4.14 UnitOfMeasure

UnitOfMeasure (abstract)	
Package:	Units of Measure
Reference:	Geographic information -- Conceptual schema language [ISO/TS 19103:2005]

J.5.4.15 Volume

Volume	
Package:	Units of Measure
Reference:	Geographic information -- Conceptual schema language [ISO/TS 19103:2005]

Annex K: Discussion paper on Out-Of-Band Results (informative)

DISCUSSION PAPER ON

Harmonising the delivery of gridded data as OM_Observation result in the INSPIRE Data Specifications based on the Observations & Measurements data model

Version 1.3
21st February 2012

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Introduction

INSPIRE Data Specification themes like Atmospheric Conditions and Meteorological Geographical Features as well as in Oceanographic Geographical Features have come to a conclusion that for large grid coverage type INSPIRE data sets of those themes, it must be possible to link from GML encoded OM_Observation instances to results of those Observations encoded in external resources encoded using binary data formats.

The version 2.9 of the INSPIRE AC-MF Data Specification summarises the out-of-band result delivery needs as follows:

> "Due to the very large volumes of items in many AC-MF data sets, the encoding of the the grid coverage result data of these data sets is typically stored in highly optimised binary file formats. Encoding of such data in textual form, like GML, would in most case result in file sizes impractical to produce, transfer over the network or consume by the users."

This kind of linking either the entire value of the GML encoded OM_Observations' result properties, or parts of them, to external files providing the actual values, is called here "out-of-band result delivery". On the other hand providing the entire OM_Observation, including the value of the result property, using the same encoding, is called here "in-band result delivery".

The purpose of this discussion paper is to provide background information on the practical issues for delivering spatial objects based on the data model of the Observations & Measurements (ISO 19156:2011) standard, and listing some in-band and out-of-band techniques for delivering O&M Observations with the grid coverage type results using INSPIRE Download Service. This paper is intended to provide additional information to the delivery and encoding sections of the INSPIRE technical guidance document "D2.9 Guidelines for the use of Observations & Measurements and Sensor Web Enablement-related standards in INSPIRE Annex II and III data specification development".

K.1 Binding existing grid coverage data sets to OM_Observations

As defined in the Implementing Rules of INSPIRE Download Services, there are two possibilities for implementing an INSPIRE Download Service: offering pre-defined data sets for download or providing a "direct access" download service with query capabilities. In many cases the data sets in the INSPIRE Themes using the O&M based data models are collections of feature instances of class OM_Observation or classes inherited from OM_Observation.

Collections of the OM_Observations served using an INSPIRE Download Service can be either pre-defined using semantic grouping (like all measurement events with all measured properties from a single meteorological observation station within one day), or be created ad-hoc as a result of the given selection criteria for the Get Spatial Objects function of a direct-access Download Service. It's recommended that the encoding and packaging of the OM_Observation instances for both direct access and non-direct access INSPIRE Download Services should as similar as possible. For the end-user's perspective accessing an non-direct access Download Service should be like accessing a direct access Download Service with a pre-defined query.

The central idea of the INSPIRE Directive must be kept in mind: the INSPIRE Web Services exist for easy and harmonised access for geospatial information across both national and thematic borders within the EU. Thus the data sets must be harmonised as much as possible within the Data Specifications for each INSPIRE theme. Further considerable financial savings can be made if the data delivery can also be harmonised between scientifically closely related INSPIRE themes like the Atmospheric Conditions & Meteorological Geographical Features and the Oceanographic Geographical Features. The O&M model is very good basis for such harmonisation within the INSPIRE themes dealing with scientific measurement and numerical prediction data sets.

The data models in O&M based INSPIRE themes take an event based perspective on the provided data sets: The main actors in the play are temporal Observation events, and a coverage data is only one of the properties of the Observation instance. In addition to this result property, the properties for the feature of interest, the observed property, the used procedure and other metadata are provided with each OM_Observation instance. On the other hand most existing binary data formats for storing scientific data sets are (grid) coverage oriented: they are designed to efficiently store and access gridded coverage data, and currently provide only limited means of encoding the other OM_Observation properties within their internal data structure. For this reason most of the currently existing scientific binary data formats do not fit very well to encoding the the O&M based INSPIRE data sets using the in-band result delivery. Even if technically possible, modifying large sets of existing data files by embedding the missing OM_Observation properties would be costly or at least impractical.

K.2 Returning OM_Observation results in-band or out-of-band

There are several different technical options for encoding the OM_Observation grid valued data. The most straight-forward options are using in-band result delivery methods with GML encoding. This option is also closest to the existing delivery mechanisms for INSPIRE Annex I themes. For large grid coverage data sets the practical limits of the XML encoding considering data transfer and data access efficiency are soon reached with these options.

The other end of the spectrum would be to use pure binary O&M in-band encodings, which would simplify the life of those users capable of decoding those formats, but on the other hand be completely inaccessible for the users only capable of understanding GML encoded data. There is ongoing work at the OGC of defining the CF-NetCDF format and data model for encoding O&M Observation data, but generally such binary data formats are not common.

The out-of-band result delivery can be seen as a middle way approach to this problem: all users capable of understanding GML encoded OM_Observations are able to get a good deal of information for deciding whether the data set is interesting enough for their use cases: the feature of interest and the sampling feature describe the geographical location of the target of the Observation, the observed property gives information on what aspects of the target have been observed, the process and the metadata can be used for finding out the details of the Observation event, and the phenomenonTime property of the OM_Observation places the event at a point in the time axis. After this initial evaluation step the users may decide to proceed with the possibly resource and time consuming operation of downloading the separately available result grid coverage.

This section presents some of the options for encoding the value of grid coverage valued result properties of OM_Observations. Both in-band and out-of-band options are included as the most feasible choice depends on the quality and the quantity of the delivered data sets.

For each example, only the om:result element of the OM_Observation instance if provided for brevity.

K.2.1 *Option 1 (in-band): Embed the result using GML Coverage encoding*

In this case a gmlcov:ReferenceableGridCoverage is used, but a gml:RectifiedGridCoverage could also be appropriate. The encoding shows an x,y,z t grid coverage

```
<om:result>
  <gmlcov:ReferenceableGridCoverage gml:id="refgrid1">
    <gml:domainSet>
      <csml:ReferenceableGridByVectors dimension="3" gml:id="refgridv1"
        srsName="urn:ogc:def:crs:EPSG:6.6:4326 ++timeCRS definition++">
        <gml:limits>
          <gml:GridEnvelope>
            <gml:low>0 0 0</gml:low>
            <gml:high>180 359 365</gml:high>
          </gml:GridEnvelope>
        </gml:limits>
        <gml:axisLabels>x y t</gml:axisLabels>
        <origin>
```

```
            <gml:Point gml:id="originID">
              <!-- the srs of this point is the srs of the external reference
system i.e. the srs
                specified in the ReferenceableGridByVectors srsName attribute -->
              <gml:pos>0 0 0</gml:pos>
            </gml:Point>
          </origin>
          <generalGridAxis>
            <GeneralGridAxis>
              <offsetVector>1 0 0</offsetVector>
              <coefficients>-90.0 -89.0 -88.0..... 88.0 89.0 90 </coefficients>
              <gridAxesSpanned>x y</gridAxesSpanned>
              <sequenceRule axisOrder="+1 +2">Linear</sequenceRule>
            </GeneralGridAxis>
          </generalGridAxis>
          <generalGridAxis>
            <GeneralGridAxis>
              <offsetVector>0 1 0</offsetVector>
              <coefficients>-180.0 -179.0 -178.0 ….178.0 179.0 180.0</coefficients>
              <gridAxesSpanned>x y</gridAxesSpanned>
              <sequenceRule axisOrder="+1 +2">Linear</sequenceRule>
            </GeneralGridAxis>
          </generalGridAxis>
          <generalGridAxis>
            <GeneralGridAxis>
              <offsetVector>0 0 1</offsetVector>
              <!-- coefficients correspond to "n days since 2010-01-01T00:00:00.0"
(the temporal crs)-->
              <coefficients>0 1 2 3 4 5 …. 362 363 364</coefficients>
              <gridAxesSpanned>t</gridAxesSpanned>
              <sequenceRule axisOrder="+1">Linear</sequenceRule>
            </GeneralGridAxis>
          </generalGridAxis>
        </csml:ReferenceableGridByVectors>
      </gml:domainSet>
      <gml:rangeSet>
        <!-- the in band measurement values that correspond to the x,y,t positions
-->
        <gml:DataBlock>
          <gml:rangeParameters />
          <gml:doubleOrNilReasonTupleList>21.2 21.3 20.1 19.3 18.4 21.3 ….. etc
</gml:doubleOrNilReasonTupleList>
        </gml:DataBlock>
      </gml:rangeSet>
      <gmlcov:rangeType>
        <swe:DataRecord>
          <swe:field name="air_temperature">
            <swe:Quantity

definition="http://sweet.jpl.nasa.gov/2.0/physThermo.owl#Temperature">
              <swe:uom code="Cel"/>
            </swe:Quantity>
          </swe:field>
        </swe:DataRecord>
      </gmlcov:rangeType>
    </gmlcov:ReferenceableGridCoverage>
  </om:result>
```

For several OM_Observation instances with the same domainSet and rangeType (like periodical new observations), the recurring parts can be re-used using XLink syntax. This makes the om:result element much more compact:

```
  <om:result>
    <gmlcov:ReferenceableGridCoverage gml:id="refgrid1">
      <gml:domainSet xlink:href="http://web.access.server.org/pre-defined/cv-23443-
```

```
timeseries.domainset.xml">
      <gml:rangeSet>
        <!-- the in band measurement values that correspond to the x,y,t positions
-->
        <gml:DataBlock>
          <gml:rangeParameters />
          <gml:doubleOrNilReasonTupleList>21.2 21.3 20.1 19.3 18.4 21.3 …... etc
</gml:doubleOrNilReasonTupleList>
        </gml:DataBlock>
      </gml:rangeSet>
      <gmlcov:rangeType xlink:href="http://web.access.server.org/pre-defined/cv-
23443-timeseries.rangetype.xml"/>
    </gmlcov:ReferenceableGridCoverage>
  </om:result>
```

Pros:

- Uses OGC standard coverage encodings.
- The domain, and rangeType are fully encoded.age encodings.

Cons:

- Encoding the rangeSet inline is not suitable for very large datasets.

K.2.2 *Option 2: (out-of-band) XLink the entire om:result*

The idea is to use the “GML way” of linking to an external resource: the XLink.

Example:

```
<om:result
  xlink:type="simple"
  xlink:href="http://web.access.server.org/pre-defined/cv-12345.nc"/>
```

Pros:

- Very simple to implement.

Cons:

- No way to define MIME type or the size of the remote file in advance, client must do "trial-and-error" by making a HTTP HEAD request first for example.
- Offers practically no information about the result (e.g. the domain of the coverage), clients unable to represent a geospatial placeholder area or point before downloading the entire binary file.

K.2.3 *Option 3 (out-of-band): Define an INSPIRE specific referencing "out-of-band" result type*

This option is semantically just an extended version of the XLink option (3), but with possibility to properly define the service interfaces.

Example:

```
  <om:result>
    <inspire_om:OutOfBandResult>
      <inspire_om:AlternativeAccessMethods>
        <inspire_om:OnlineAccessService>

<inspire_om:serviceAddress>http://data.access.server.org/wcs</inspire_om:serviceAdd
ress>

<inspire_om:protocol>http://www.opengis.net/spec/WCS/2.0</inspire_om:protocol>
          <inspire_om:dataIdentifier>cv-12345</inspire_om:dataIdentifier>
          <inspire_om:queryMethod>GetCoverage</inspire_om:queryMethod>
        </inspire_om:OnlineAccessService>
        <inspire_om:OnlineAccessService>

<inspire_om:serviceAddress>ftp://ftp.access.server.org</inspire_om:serviceAddress>
          <inspire_om:protocol>FTP</inspire_om:protocol>
          <inspire_om:dataIdentifier>/pre-defined/cv-
12345.nc</inspire_om:dataIdentifier>
          <inspire_om:queryMethod>RETR</inspire_om:queryMethod>
        </inspire_om:OnlineAccessService>
        <inspire_om:OnlineAccessService>

<inspire_om:serviceAddress>http://web.access.server.org</inspire_om:serviceAddress>
          <inspire_om:protocol>HTTP</inspire_om:protocol>
          <inspire_om:dataIdentifier>/pre-defined/cv-
12345.nc</inspire_om:dataIdentifier>
          <inspire_om:queryMethod>GET</inspire_om:queryMethod>
        </inspire_om:OnlineAccessService>
      </inspire_om:AlternativeAccessMethods>
    </inspire_om:OutOfBandResult>
  </om:result>
```

Pros:

- Can be used with no model conflicts for those OM_Observation types that do not restrict the result type.
- Possibility to give alternative access methods for a result coverage.

Cons:

- Does not comply to the current version of SamplingCoverageObservation (or the EnvironmentalSamplingObservation or what ever it will be called in the final INSPIRE OM model): the om:result OutOfBandResult is not of type DiscreteCoverage, would need to be changed to allow either a DiscreteCoverage or an OutOfBandResult
- Mixes the the model content and the network service semantics, but on the other hand, so does any of the proposed out-of-band options.
- INSPIRE specific solution, no existing community support.
- Offers very little information about the result (e.g. the domain of the coverage).

K.2.4 *Option 4 (out-of-band): Link to an external rangeSet using gml:File*

This option tries to follow the existing methods in GML for referencing external resources (gml:File), but it also tries to "slip in" the possibility for knowledgeable clients to use alternative methods for accessing the coverage range data or a subset of it.

Example:

```
  <om:result>
    <gmlcov:ReferenceableGridCoverage gml:id="refgrid1">
      <gml:domainSet>
        <csml:ReferenceableGridByVectors dimension="3" gml:id="refgridv1"
          srsName="urn:ogc:def:crs:EPSG:6.6:4326 ++timeCRS definition++">
          <gml:limits>
            <gml:GridEnvelope>
              <gml:low>0 0 0</gml:low>
              <gml:high>180 359 365</gml:high>
            </gml:GridEnvelope>
          </gml:limits>
          <gml:axisLabels>x y t</gml:axisLabels>
          <origin>
            <gml:Point gml:id="originID">
              <!-- the srs of this point is the srs of the external reference
system i.e. the srs
                specified in the ReferenceableGridByVectors srsName attribute -->
              <gml:pos>0 0 0</gml:pos>
            </gml:Point>
          </origin>
          <generalGridAxis>
            <GeneralGridAxis>
              <offsetVector>1 0 0</offsetVector>
              <coefficients>-90.0 -89.0 -88.0..... 88.0 89.0 90 </coefficients>
              <gridAxesSpanned>x y</gridAxesSpanned>
              <sequenceRule axisOrder="+1 +2">Linear</sequenceRule>
            </GeneralGridAxis>
          </generalGridAxis>
          <generalGridAxis>
            <GeneralGridAxis>
              <offsetVector>0 1 0</offsetVector>
              <coefficients>-180.0 -179.0 -178.0 ….178.0 179.0 180.0</coefficients>
              <gridAxesSpanned>x y</gridAxesSpanned>
              <sequenceRule axisOrder="+1 +2">Linear</sequenceRule>
            </GeneralGridAxis>
          </generalGridAxis>
          <generalGridAxis>
            <GeneralGridAxis>
              <offsetVector>0 0 1</offsetVector>
              <!-- coefficients correspond to "n days since 2010-01-01T00:00:00.0"
(the temporal crs)-->
              <coefficients>0 1 2 3 4 5 …. 362 363 364</coefficients>
              <gridAxesSpanned>t</gridAxesSpanned>
              <sequenceRule axisOrder="+1">Linear</sequenceRule>
            </GeneralGridAxis>
          </generalGridAxis>
        </csml:ReferenceableGridByVectors>
      </gml:domainSet>
      <gml:rangeSet>
        <gml:File>
          <gml:rangeParameters>
            <inspire_om:ExternalStorageDescriptor>
              <inspire_om:descriptor>
                <inspire_om:NetCDFExtract>
                <inspire_om:variableName>air_temperature</inspire_om::variableName>
                </inspire_om:NetCDFExtract>
              </inspire_om:descriptor>
            </inspire_om:ExternalStorageDescriptor>
          </gml:rangeParameters>
          <gml:fileReference>http://web.access.server.org/pre-defined/cv-
12345.nc</gml:fileReference>
          <gml:fileStructure codeSpace="cf-conventions-
version">1.6</gml:fileStructure>
          <gml:mimeType>application/x-netcdf</gml:mimeType>
        </gml:File>
```

```
      </gml:rangeSet>
      <gmlcov:rangeType>
        <swe:DataRecord>
          <swe:field name="airTemperature">
            <swe:Quantity
             definition="http://sweet.jpl.nasa.gov/2.0/physThermo.owl#Temperature">
              <swe:uom code="Cel"/>
            </swe:Quantity>
          </swe:field>
        </swe:DataRecord>
      </gmlcov:rangeType>
    </gmlcov:ReferenceableGridCoverage>
  </om:result>
```

The ExternalStorageDescriptor element placed within the gml:rangeParameters element is almost identical to the CSMLStorageDescriptor element. The abstract FileExtractType is however simplified for the out-of-band use by leaving out the mandatory arraySize and fileName properties, as well as the optional uom and numericType properties used for defining embedded numeric data array structures inherited in CSML from the abstract ArrayDescriptorType. The NetCDFExtract element in the example above tells the client that only the air_temperature variable values within the referred NetCDF file form the rangeSet of this coverage.

Besides the NetCDFExtract, there is also a GRIBExtract element defined in CSML. This is also copied to the XML schema of Annex I.

As with option 1, several OM_Observation instances with the same domainSet and rangeType (like periodical new observations), could re-use these elements for more compact encoding:

```
  <om:result>
    <gmlcov:ReferenceableGridCoverage gml:id="refgrid1">
      <gml:domainSet xlink:href="http://web.access.server.org/pre-defined/cv-23443-
timeseries.domainset.xml">
      <gml:rangeSet>
        <gml:File>
          <gml:rangeParameters>
            <inspire_om:ExternalStorageDescriptor>
              <inspire_om:descriptor>
                <inspire_om:NetCDFExtract>

<inspire_om:variableName>air_temperature</inspire_om:variableName>
                </inspire_om:NetCDFExtract>
              </inspire_om:descriptor>
            </inspire_om:ExternalStorageDescriptor>
          </gml:rangeParameters>
          <gml:fileReference>http://web.access.server.org/pre-defined/cv-
12345.nc</gml:fileReference>
          <gml:fileStructure codeSpace="cf-conventions-
version">1.6</gml:fileStructure>
          <gml:mimeType>application/x-netcdf</gml:mimeType>
        </gml:File>
      </gml:rangeSet>
      <gmlcov:rangeType xlink:href="http://web.access.server.org/pre-defined/cv-
23443-timeseries.rangetype.xml"/>
    </gmlcov:ReferenceableGridCoverage>
  </om:result>
```

Pros:

- We don’t break the current model: om:result for the SamplingGridCoverage is of type DiscreteCoverage.
- Follows the GML standard GML coverage encoding model.

- Even if the clients cannot understand the rangeParameters, they are able to access the entire binary file using the fileReference and mimeType properties (provided that they understand the gml:File).

Cons:

- The external binary files typically contain the entire coverage description, not just the rangeSet. Actually we should probably point inside the binary files in gml:File to access the rangeSet directly. This kind of internal references are often file format specific, if they exist at all.
- Possibly slight misuse of gml:rangeParameters: the GML schema say it should be used for "semantics of the range set".

K.2.5 *Option 5 (out-of-band): gml:File with AlternativeEncodings*

This is option is very similar to the option 4, but it adds possibility to provide alternative access methods to retrieve the coverage data. The elements used for this are the same as in option 3, but this time they are provided within the gml:rangeParameters.

Example:

```
  <om:result>
    <gmlcov:ReferenceableGridCoverage gml:id="refgrid1">
      <gml:domainSet xlink:href="http://web.access.server.org/pre-defined/cv-23443-
timeseries.domainset.xml">
      <gml:rangeSet>
        <gml:File>
          <gml:rangeParameters>
            <inspire_om:AlternativeAccessMethods>
              <inspire_om:OnlineAccessService>

<inspire_om:serviceAddress>http://data.access.server.org/wcs</inspire_om:serviceAdd
ress>

<inspire_om:protocol>http://www.opengis.net/spec/WCS/2.0</inspire_om:protocol>
                <inspire_om:dataIdentifier>cv-12345</inspire_om:dataIdentifier>
                <inspire_om:queryMethod>GetCoverage</inspire_om:queryMethod>
              </inspire_om:OnlineAccessService>
              <inspire_om:OnlineAccessService>

<inspire_om:serviceAddress>ftp://ftp.access.server.org</inspire_om:serviceAddress>
                <inspire_om:protocol>FTP</inspire_om:protocol>
                <inspire_om:dataIdentifier>/pre-defined/cv-
12345.nc</inspire_om:dataIdentifier>
                <inspire_om:queryMethod>RETR</inspire_om:queryMethod>
              </inspire_om:OnlineAccessService>
              <inspire_om:OnlineAccessService>

<inspire_om:serviceAddress>http://web.access.server.org</inspire_om:serviceAddress>
                <inspire_om:protocol>HTTP</inspire_om:protocol>
                <inspire_om:dataIdentifier>/pre-defined/cv-
12345.nc</inspire_om:dataIdentifier>
                <inspire_om:queryMethod>GET+NetCDFExtract</inspire_om:queryMethod>
                <inspire_om:accessParameters>
                  <inspire_om:ExternalStorageDescriptor>
                    <inspire_om:descriptor>
                      <inspire_om:NetCDFExtract>

<inspire_om:variableName>air_temperature</inspire_om:variableName>
                      </inspire_om:NetCDFExtract>
                    </inspire_om:descriptor>
                  </inspire_om:ExternalStorageDescriptor>
                </inspire_om:accessParameters>
```

```
            </inspire_om:OnlineAccessService>
          </inspire_om:AlternativeAccessMethods>
</gml:rangeParameters>
          <gml:fileReference>http://web.access.server.org/pre-defined/cv-
12345.nc</gml:fileReference>
          <gml:fileStructure codeSpace="cf-conventions-
version">1.6</gml:fileStructure>
          <gml:mimeType>application/x-netcdf</gml:mimeType>
        </gml:File>
      </gml:rangeSet>
      <gmlcov:rangeType xlink:href="http://web.access.server.org/pre-defined/cv-
23443-timeseries.rangetype.xml"/>
    </gmlcov:ReferenceableGridCoverage>
  </om:result>
```

Pros:

- Follows standard GML coverage encoding
- Possibility to give alternative access methods for a result coverage, including service interfaces for returning only part of the entire coverage based on users' requirements.

Cons:

- A bit of a hack to provide references to alternative access methods inside the gml:File element: those access methods should really be one level up, but there does not seem to be a an appropriate extension point in GML at that level.

K.2.6 *Option 6 (out-of-band): Using SWE Common DataStream & BinaryEncoding*

The SWE Common also has means of referring to external, binary encoded data arrays. In the following example the value of the om:result is a swe:DataStream representing a 3000 by 3000 pixel raster image, with colors of each pixel encoded using one unsigned byte for each three components: red, green and blue:

Example:

```
  <om:result>
    <swe:DataStream id="EXAMPLE_03">
      <!-- -->
      <swe:elementType name="imageData">
        <swe:DataArray definition="http://sweet.jpl.nasa.gov/2.0/info.owl#Raster">
          <swe:elementCount>
            <swe:Count>
              <swe:value>3000</swe:value>
            </swe:Count>
          </swe:elementCount>
          <swe:elementType name="row">
            <swe:DataArray definition="http://sweet.jpl.nasa.gov/2.0/info.owl#Row">
              <swe:elementCount>
                <swe:Count>
                  <swe:value>3000</swe:value>
                </swe:Count>
              </swe:elementCount>
              <swe:elementType name="pixel">
                <swe:DataRecord
definition="http://sweet.jpl.nasa.gov/2.0/info.owl#Cell">
                  <swe:field name="red">
                    <swe:Count
definition="http://sweet.jpl.nasa.gov/2.0/physRadiation.owl#Radiance">
                      <swe:description>
                        Radiance measured on band1 usually assigned to red channel
                      </swe:description>
```

```
                      <swe:nilValues>
                        <swe:NilValues id="NIL_VALUES">
                          <swe:nilValue
reason="http://www.opengis.net/def/nil/OGC/0/BelowDetectionRange">0</swe:nilValue>
                          <swe:nilValue
reason="http://www.opengis.net/def/nil/OGC/0/AboveDetectionRange">255</swe:nilValue
>
                        </swe:NilValues>
                      </swe:nilValues>
                    </swe:Count>
                  </swe:field>
                  <swe:field name="green">
                    <swe:Count
definition="http://sweet.jpl.nasa.gov/2.0/physRadiation.owl#Radiance">
                      <swe:description>
                        Radiance measured on band2 usually assigned to green
channel
                      </swe:description>
                      <swe:nilValues xlink:href="#NIL_VALUES"/>
                    </swe:Count>
                  </swe:field>
                  <swe:field name="blue">
                    <swe:Count
definition="http://sweet.jpl.nasa.gov/2.0/physRadiation.owl#Radiance">
                      <swe:description>
                        Radiance measured on band3 usually assigned to blue channel
                      </swe:description>
                      <swe:nilValues xlink:href="#NIL_VALUES"/>
                    </swe:Count>
                  </swe:field>
                </swe:DataRecord>
              </swe:elementType>
            </swe:DataArray>
          </swe:elementType>
        </swe:DataArray>
      </swe:elementType>
      <!-- -->
      <swe:encoding>
        <swe:BinaryEncoding byteEncoding="raw" byteOrder="bigEndian">
          <swe:member>
            <swe:Component ref="imageData/row/pixel/red"
dataType="http://www.opengis.net/def/dataType/OGC/0/unsignedByte"/>
          </swe:member>
          <swe:member>
            <swe:Component ref="imageData/row/pixel/green"
dataType="uhttp://www.opengis.net/def/dataType/OGC/0/unsignedByte"/>
          </swe:member>
          <swe:member>
            <swe:Component ref="imageData/row/pixel/blue"
dataType="http://www.opengis.net/def/dataType/OGC/0/unsignedByte"/>
          </swe:member>
        </swe:BinaryEncoding>
      </swe:encoding>
      <!-- -->
      <swe:values xlink:href="http://mydomain.net/myimage.raw"/>
    </swe:DataStream>
  </om:result>
```

Pros:

- SWE Common is an OGC standard and widely used, no need to create an INSPIRE specific solution.
- The structure of the referenced data array is well defined in the GML encoding, so the clients know what to expect when downloading the binary encoded part.

Cons:

- The om:result does not define a coverage: there is not explicit definition of the spatial and/or temporal locations of the grid points. The result is just an array of data cells. The clients are not able to map the values to a geospatial area and/or on the time axis without added information.

K.2.7 *Option 7 CSML Pattern*

TBD

K.3 XML Schema definitions for the proposed out-of-band result types

```
<?xml version="1.0" encoding="UTF-8"?>
<schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
xmlns="http://www.w3.org/2001/XMLSchema"
xmlns:gmlcov="http://www.opengis.net/gmlcov/1.0"
  xmlns:gml="http://www.opengis.net/gml/3.2"
  xmlns:xlink="http://www.w3.org/1999/xlink"
  xmlns:inspire_om="http://inspire.jrc.ec.europa.eu/schemas/om_common/3.0"
  elementFormDefault="qualified"
  targetNamespace="http://inspire.jrc.ec.europa.eu/schemas/om_common/3.0">

  <import namespace="http://www.opengis.net/gml/3.2"
schemaLocation="http://schemas.opengis.net/gml/3.2.1/gml.xsd"/>
  <import namespace="http://www.w3.org/1999/xlink"
schemaLocation="http://schemas.opengis.net/xlink/1.0.0/xlinks.xsd"/>

  <element name="OnlineAccessService" type="inspire_om:OnlineAccessServiceType"/>

  <complexType name="OnlineAccessServiceType">
    <sequence>
      <element name="serviceAddress" type="anyURI"/>
      <element name="protocol" type="anyURI"/>
      <element name="dataIdentifier" type="anyURI"/>
      <element name="queryMethod" type="anyURI" minOccurs="0"/>
      <element name="accessParameters" type="gml:AssociationRoleType"
minOccurs="0"/>
    </sequence>
  </complexType>

  <element name="AlternativeAccessMethods"
type="inspire_om:AlternativeAccessMethodArrayType"/>

  <complexType name="AlternativeAccessMethodArrayType">
    <sequence>
      <element ref="inspire_om:OnlineAccessService" minOccurs="1"
maxOccurs="unbounded"/>
    </sequence>
  </complexType>

  <element name="OutOfBandResult" type="inspire_om:OutOfBandResultType"/>

  <complexType name="OutOfBandResultType">
    <sequence>
      <element ref="inspire_om:AlternativeAccessMethods"/>
    </sequence>
  </complexType>

  <!--================================================================== -->
  <!--===== Root storage descriptor element =====-->
```

```
  <!--===== Modeled closely after the CSMLStorageDescriptor ======= -->
  <!--=================================================================== -->
  <complexType name="ExternalStorageDescriptorType">
    <sequence>
      <element name="descriptor" minOccurs="0" maxOccurs="unbounded">
        <complexType>
          <sequence>
            <element ref="inspire_om:FileExtract"/>
          </sequence>
        </complexType>
      </element>
    </sequence>
  </complexType>
  <element name="ExternalStorageDescriptor"
type="inspire_om:ExternalStorageDescriptorType"/>
  <complexType name="CSMLStorageDescriptorPropertyType">
    <sequence>
      <element ref="inspire_om:ExternalStorageDescriptor"/>
    </sequence>
  </complexType>
  <!--=================================================================== -->
  <complexType name="FileExtractType" abstract="true">
    <annotation>
      <documentation>.</documentation>
    </annotation>
  </complexType>

  <element name="FileExtract" type="inspire_om:FileExtractType" abstract="true"/

  <!--=================================================================== -->
  <complexType name="NetCDFExtractType">
    <complexContent>
      <extension base="inspire_om:FileExtractType">
        <sequence>
          <element name="variableName" type="string"/>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <element name="NetCDFExtract" type="inspire_om:NetCDFExtractType"
substitutionGroup="inspire_om:FileExtract"/>
  <complexType name="NetCDFExtractPropertyType">
    <sequence>
      <element ref="inspire_om:NetCDFExtract"/>
    </sequence>
  </complexType>

  <!--=================================================================== -->
  <complexType name="GRIBExtractType">
    <complexContent>
      <extension base="inspire_om:FileExtractType">
        <sequence>
          <element name="parameterCode" type="int"/>
          <element name="recordNumber" type="int" minOccurs="0"/>
          <element name="fileOffset" type="int" minOccurs="0"/>
          <element name="ctlVariableName" type="string" minOccurs="0"/>
        </sequence>
      </extension>
    </complexContent>
  </complexType>
  <element name="GRIBExtract" type="inspire_om:GRIBExtractType"
substitutionGroup="inspire_om:FileExtract"/>
  <complexType name="GRIBExtractPropertyType">
    <sequence>
      <element ref="inspire_om:GRIBExtract"/>
    </sequence>
```

```
  </complexType>
</schema>
```

Annex L: Examples (informative)

L.1 INSPIRE specialised observations

This section containts examples of use of INSPIRE specialised observations

L.1.1 *PointTimeSeries Observation*

This example concerns repeated measurements of groundwater level (timeseries) at a fiexd location.

```xml
<?xml version="1.0" encoding="UTF-8"?>
<sos:GetObservationResponse xmlns:xlink="http://www.w3.org/1999/xlink"
xmlns:sos="http://www.opengis.net/sos/2.0" xmlns:xsi="http://www.w3.org/2001/XMLSchema-
instance" xsi:schemaLocation="http://inspire.ec.europa.eu/schemas/omso/3.0
http://inspire.ec.europa.eu/schemas/omso/3.0/SpecialisedObservations.xsd
http://www.opengis.net/sos/2.0 http://schemas.opengis.net/sos/2.0/sos.xsd">
    <sos:observationData>
        <omso:PointTimeSeriesObservation xmlns:xlink="http://www.w3.org/1999/xlink"
xmlns:om="http://www.opengis.net/om/2.0" xmlns:gml="http://www.opengis.net/gml/3.2"
xmlns:wml2="http://www.opengis.net/waterml/2.0"
xmlns:omso="http://inspire.ec.europa.eu/schemas/omso/3.0" gml:id="o_1">
            <gml:identifier
codeSpace="http://www.opengis.net/def/nil/OGC/0/unknown">http://ressource.brgm-
rec.fr/obs/RawSeriePiezo/00463X0036/H1.2-622</gml:identifier>
            <om:type
xlink:href="http://inspire.ec.europa.eu/featureconcept/PointTimeSeriesObservation"/>
            <om:phenomenonTime>
                <gml:TimePeriod xmlns:gml="http://www.opengis.net/gml/3.2"
gml:id="phenomenonTime_1">
                    <gml:beginPosition>2015-12-31T09:00:00.000Z</gml:beginPosition>
                    <gml:endPosition>2016-10-27T08:00:00.000Z</gml:endPosition>
                </gml:TimePeriod>
            </om:phenomenonTime>
            <om:resultTime>
                <gml:TimeInstant xmlns:gml="http://www.opengis.net/gml/3.2"
gml:id="ti_9E76EC910D8AC9F1D7CFA6658448F23F0A13F914">
                    <gml:timePosition>2016-10-27T08:00:00.000Z</gml:timePosition>
                </gml:TimeInstant>
            </om:resultTime>
            <om:procedure xlink:href="http://id.eaufrance.fr/met/403.xml" xlink:title="Electronic
piezometric probe"/>
            <om:parameter>
                <om:NamedValue xmlns:om="http://www.opengis.net/om/2.0"
xmlns:xlink="http://www.w3.org/1999/xlink" xmlns:xsi="http://www.w3.org/2001/XMLSchema-
instance">
                    <om:name xlink:href="RelatedMonitoringFeature"/>
                    <om:value xmlns:ns="http://www.opengis.net/gml/3.2"
xlink:href="http://ressource.brgm-rec.fr/data/Piezometre/00463X0036/H1.2"
xsi:type="ns:ReferenceType"/>
                </om:NamedValue>
            </om:parameter>
            <om:parameter>
```

```xml
        <om:NamedValue xmlns:om="http://www.opengis.net/om/2.0"
xmlns:xlink="http://www.w3.org/1999/xlink" xmlns:xsi="http://www.w3.org/2001/XMLSchema-
instance">
          <om:name xlink:href="http://www.opengis.net/def/param-name/OGC-
OM/2.0/samplingGeometry"/>
          <om:value xmlns:ns="http://www.opengis.net/gml/3.2"
xsi:type="ns:GeometryPropertyType">
            <ns:Point ns:id="Point_sp_8AE6F77817E65AF9A418CFECE697200014947610">
              <ns:pos
srsName="http://www.opengis.net/def/crs/EPSG/0/4326">49.9506859240222
2.3597603712661</ns:pos>
            </ns:Point>
          </om:value>
        </om:NamedValue>
      </om:parameter>
      <om:parameter>
        <om:NamedValue xmlns:om="http://www.opengis.net/om/2.0"
xmlns:xlink="http://www.w3.org/1999/xlink" xmlns:xsi="http://www.w3.org/2001/XMLSchema-
instance">
          <om:name xlink:href="observationQualification"/>
          <om:value xmlns:ns="http://www.opengis.net/gml/3.2"
xlink:href="http://www.sandre.eaufrance.fr/?urn=urn:sandre:donnees:414::CdElement:0:::referentiel:3.
1:xml" xsi:type="ns:ReferenceType"/>
        </om:NamedValue>
      </om:parameter>
      <om:parameter>
        <om:NamedValue xmlns:om="http://www.opengis.net/om/2.0"
xmlns:xlink="http://www.w3.org/1999/xlink" xmlns:xsi="http://www.w3.org/2001/XMLSchema-
instance">
          <om:name xlink:href="observationStatus"/>
          <om:value xmlns:ns="http://www.opengis.net/gml/3.2"
xlink:href="http://www.sandre.eaufrance.fr/?urn=urn:sandre:donnees:415::CdElement:1:::referentiel:3.
1:xml" xsi:type="ns:ReferenceType"/>
        </om:NamedValue>
      </om:parameter>
      <om:observedProperty xlink:href="http://id.eaufrance.fr/par/1689.xml"
xlink:title="GroundWaterLevel"/>
      <om:featureOfInterest>
        <sams:SF_SpatialSamplingFeature
xmlns:sams="http://www.opengis.net/samplingSpatial/2.0"
xmlns:sf="http://www.opengis.net/sampling/2.0"
gml:id="ssf_CA2904E6002BEA5D03FBA28690BABF90168728A9">
          <gml:description>SF_SamplingPoint representation of French Water Information
System's EnvironmentalMonitoringFacility 'Piezometre'</gml:description>
          <gml:identifier codeSpace="">http://ressource.brgm-
rec.fr/data/Piezometre/00463X0036/H1.2</gml:identifier>
          <gml:name codeSpace="http://www.opengis.net/def/nil/OGC/0/unknown">Piezo
00463X0036/H1.2</gml:name>
          <sf:type xlink:href="http://www.opengis.net/def/samplingFeatureType/OGC-
OM/2.0/SF_SamplingPoint"/>
          <sf:sampledFeature xlink:href="Aquifer"/>
          <sams:shape>
            <gml:Point
gml:id="Point_ssf_CA2904E6002BEA5D03FBA28690BABF90168728A9">
              <gml:pos
srsName="http://www.opengis.net/def/crs/EPSG/0/4326">49.9506859240222
2.3597603712661</gml:pos>
            </gml:Point>
          </sams:shape>
        </sams:SF_SpatialSamplingFeature>
```

```
            </om:featureOfInterest>
            <om:result>
                <wml2:MeasurementTimeseries gml:id="timeseries.1">
                    <wml2:metadata>
                        <wml2:MeasurementTimeseriesMetadata>
                            <wml2:temporalExtent xlink:href="#phenomenonTime_1"/>
                        </wml2:MeasurementTimeseriesMetadata>
                    </wml2:metadata>
                    <wml2:defaultPointMetadata>
                        <wml2:DefaultTVPMeasurementMetadata>
                            <wml2:uom code="m"/>
                            <wml2:interpolationType
xlink:href="http://www.opengis.net/def/timeseriesType/WaterML/2.0/continuous"
xlink:title="Instantaneous"/>
                        </wml2:DefaultTVPMeasurementMetadata>
                    </wml2:defaultPointMetadata>
                    <wml2:point>
                        <wml2:MeasurementTVP>
                            <wml2:time>2015-12-31T09:00:00.000Z</wml2:time>
                            <wml2:value>45.47</wml2:value>
                        </wml2:MeasurementTVP>
                    </wml2:point>
                    <wml2:point>
                        <wml2:MeasurementTVP>
                            <wml2:time>2015-12-31T10:00:00.000Z</wml2:time>
                            <wml2:value>45.47</wml2:value>
                        </wml2:MeasurementTVP>
                </wml2:point>
                    <wml2:point>
                        <wml2:MeasurementTVP>
                            <wml2:time>2015-12-31T11:00:00.000Z</wml2:time>
                            <wml2:value>45.47</wml2:value>
                        </wml2:MeasurementTVP>
                    </wml2:point>
                    <wml2:point>
                        <wml2:MeasurementTVP>
                            <wml2:time>2015-12-31T12:00:00.000Z</wml2:time>
                            <wml2:value>45.47</wml2:value>
                        </wml2:MeasurementTVP>
                </wml2:point>
…
                </wml2:MeasurementTimeseries>
            </om:result>
        </omso:PointTimeSeriesObservation>
    </sos:observationData>
</sos:GetObservationResponse>
```


L.1.2 *Trajectory Observation*

This example concerns repeated measurements of water temperature (timeseries) along a ship trajectory.


```
<?xml version="1.0" encoding="UTF-8"?>
<omso:TrajectoryObservation gml:id="o_AD6E535CC0E6B01CF518D4E953782B220D39CF5D"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns:om="http://www.opengis.net/om/2.0"
xmlns:gml="http://www.opengis.net/gml/3.2" xmlns:xlink="http://www.w3.org/1999/xlink"
xmlns:wml2="http://www.opengis.net/waterml/2.0"
xmlns:omso="http://inspire.ec.europa.eu/schemas/omso/3.0"
```

```
xsi:schemaLocation="http://www.opengis.net/om/2.0
http://schemas.opengis.net/om/2.0/observation.xsd http://www.opengis.net/gml/3.2
```

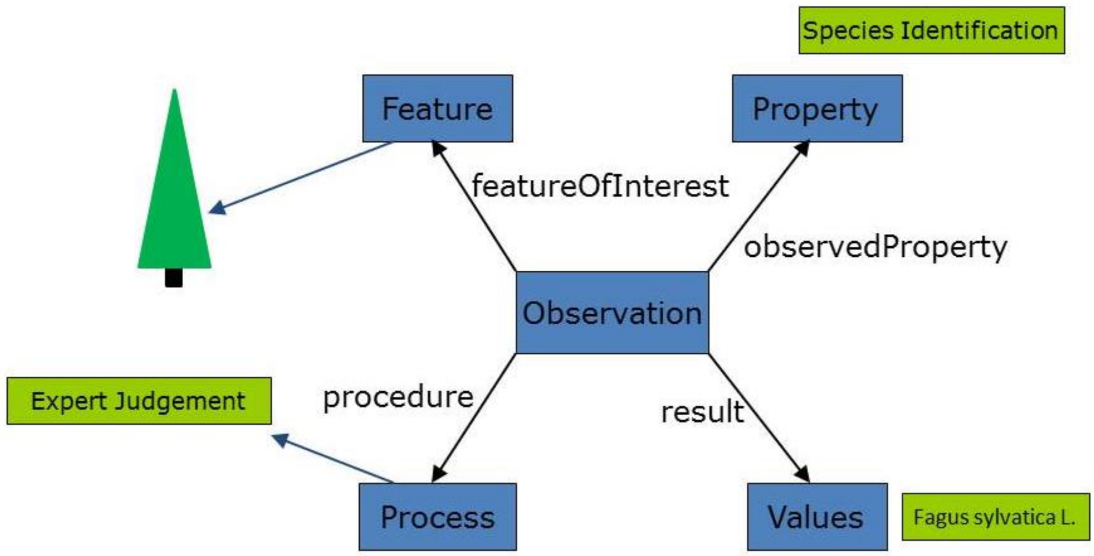
L.2 SWE Common Results

The following section shows how a single result can be provided via the use of the result types provided by OGC SWE Common. The first example provides a measurement as the result (concentration of ozone in µg/m³):

```xml
<?xml version="1.0" encoding="UTF-8"?>
<sos:GetObservationResponse xmlns:sos="http://www.opengis.net/sos/2.0"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns:om="http://www.opengis.net/om/2.0"
xmlns:gml="http://www.opengis.net/gml/3.2" xmlns:xlink="http://www.w3.org/1999/xlink"
xmlns:swe="http://www.opengis.net/swe/2.0" xsi:schemaLocation="http://www.opengis.net/sos/2.0
http://schemas.opengis.net/sos/2.0/sosGetObservation.xsd http://www.opengis.net/gml/3.2
http://schemas.opengis.net/gml/3.2.1/gml.xsd http://www.opengis.net/om/2.0
http://schemas.opengis.net/om/2.0/observation.xsd">
    <sos:observationData>
        <om:OM_Observation gml:id="Obs1">
            <om:phenomenonTime>
                <gml:TimeInstant gml:id="Time1">
                    <gml:timePosition>2008-09-01T02:00:00+0200</gml:timePosition>
                </gml:TimeInstant>
            </om:phenomenonTime>
            <om:resultTime>
                <gml:TimeInstant gml:id="Time2">
                    <gml:timePosition>2008-09-01T05:00:00+0200</gml:timePosition>
                </gml:TimeInstant>
            </om:resultTime>
            <om:procedure xlink:href="http://some-server.xxx/xxIdOfTheProcedure"/>
            <om:parameter>
                <om:NamedValue>
                    <om:name xlink:href="relatedMonitoringFeature"/>
                    <om:value xsi:type="gml:ReferenceType" xlink:href="'http://some-
server.xxx/xxIdOfTheMonitoringFeature"/>
                </om:NamedValue>
            </om:parameter>
            <om:observedProperty xlink:href="urn:ogc:def:phenomenon:ait:O3"/>
            <om:featureOfInterest>
                <gml:FeatureCollection gml:id="FoI1">
                    <gml:featureMember xlink:href="http://some-server.xxx/ait/09/AT0098A"/>
                </gml:FeatureCollection>
            </om:featureOfInterest>
            <om:result>
                <swe:Quantity>
                    <swe:uom code="ug/m2"/>
                    <swe:value>28.614536</swe:value>
                </swe:Quantity>
            </om:result>
        </om:OM_Observation>
    </sos:observationData>
</sos:GetObservationResponse>
```

The second example provides a single result; however, in this example the result is not coming from a measurement, but is the result of an observation determining the species of an individual tree.
This biodiversity example illustrates the identification of an individual of a specific species. The featureOfInterest will again be defined as a “species occurrence point” as introduced in chapter 6.2.2.1 PointObservation

The featureOfInterest cannot be modelled as an occurrence of a specific species as this identification is actually an observation on the individual; at a later time it may be determined that this individual is actually of a different species, which can then be provided as an updated observation.



A swe:Category type is used for this type of categorization and additionally provide the codespace this entry was taken from, as well as a human readable description in addition to the GUID uniquely identifying this species within the codespace:

```
<?xml version="1.0" encoding="UTF-8"?>
<sos:GetObservationResponse xmlns:sos="http://www.opengis.net/sos/2.0"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns:om="http://www.opengis.net/om/2.0"
xmlns:gml="http://www.opengis.net/gml/3.2" xmlns:xlink="http://www.w3.org/1999/xlink"
xmlns:sams="http://www.opengis.net/samplingSpatial/2.0"
xmlns:sf="http://www.opengis.net/sampling/2.0" xmlns:swe="http://www.opengis.net/swe/2.0"
xsi:schemaLocation="http://www.opengis.net/sos/2.0
http://schemas.opengis.net/sos/2.0/sosGetObservation.xsd http://www.opengis.net/gml/3.2
http://schemas.opengis.net/gml/3.2.1/gml.xsd http://www.opengis.net/om/2.0
http://schemas.opengis.net/om/2.0/observation.xsd">
    <sos:observationData>
        <om:OM_Observation gml:id="Obs1">
            <om:phenomenonTime>
                <gml:TimeInstant gml:id="Time1">
                    <gml:timePosition>2008-09-01T02:00:00+0200</gml:timePosition>
                </gml:TimeInstant>
            </om:phenomenonTime>
            <om:resultTime>
                <gml:TimeInstant gml:id="Time2">
                    <gml:timePosition>2008-09-01T05:00:00+0200</gml:timePosition>
                </gml:TimeInstant>
            </om:resultTime>
            <om:procedure xlink:href="urn:ogc:object:species:identification:expertJudgement"/>
            <om:observedProperty xlink:href="urn:ogc:def:phenomenon:species:identification"/>
            <om:featureOfInterest>
                <sams:SF_SpatialSamplingFeature gml:id="SpeciesOccurencePoint.1">
                    <gml:identifier
codeSpace="http://www.someCodespacexxx">'http://someURL'</gml:identifier>
                    <sf:type xlink:href="http://www.opengis.net/def/samplingFeatureType/OGC-
OM/2.0/SF_SamplingPoint"/>
                    <sf:sampledFeature
xlink:href="https://sweet.jpl.nasa.gov/2.3/realmBiolBiome.owl#Forest" />
```

```
                <sams:shape>
                    <gml:Point gml:id="point_SpeciesOccurencePoint.1">
                        <gml:pos srsName="http://www.opengis.net/def/crs/EPSG/0/4326">49.683748
4.715314</gml:pos>
                    </gml:Point>
                </sams:shape>
            </sams:SF_SpatialSamplingFeature>
        </om:featureOfInterest>
        <om:result>
            <swe:Category>
                <swe:description>Fagus sylvatica L.</swe:description>
                <swe:codeSpace xlink:href="http://www.eu-nomen.eu/"/>
                <swe:value>68C1AC04-391B-49DF-990A-3DD6A75D05B6</swe:value>
            </swe:Category>
        </om:result>
    </om:OM_Observation>
  </sos:observationData>
</sos:GetObservationResponse>
```


The following section shows how a time series can be provided via the use of the result types provided by OGC SWE Common. In this example the observation pertains to hourly ozone measurements; the time series provided has been truncated to 3 values for brevity:


```
<?xml version="1.0" encoding="UTF-8"?>
<sos:GetObservationResponse xmlns:sos="http://www.opengis.net/sos/2.0"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns:om="http://www.opengis.net/om/2.0"
xmlns:gml="http://www.opengis.net/gml/3.2" xmlns:xlink="http://www.w3.org/1999/xlink"
xmlns:swe="http://www.opengis.net/swe/2.0" xsi:schemaLocation="http://www.opengis.net/sos/2.0
http://schemas.opengis.net/sos/2.0/sosGetObservation.xsd http://www.opengis.net/gml/3.2
http://schemas.opengis.net/gml/3.2.1/gml.xsd http://www.opengis.net/om/2.0
http://schemas.opengis.net/om/2.0/observation.xsd">
  <sos:observationData>
    <om:OM_Observation gml:id="Obs1">
        <om:phenomenonTime>
            <gml:TimePeriod gml:id="Time1" xsi:type="gml:TimePeriodType">
                <gml:beginPosition>2008-09-01T02:00:00+0200</gml:beginPosition>
                <gml:endPosition>2008-09-01T05:00:00+0200</gml:endPosition>
            </gml:TimePeriod>
        </om:phenomenonTime>
        <om:resultTime>
            <gml:TimeInstant gml:id="Time2">
                <gml:timePosition>2008-09-01T05:00:00+0200</gml:timePosition>
            </gml:TimeInstant>
        </om:resultTime>
        <om:procedure xlink:href="http://some-server.xxx/xxIdOfTheProcedure"/>
        <om:parameter>
            <om:NamedValue>
                <om:name xlink:href="relatedMonitoringFeature"/>
                <om:value xsi:type="gml:ReferenceType" xlink:href=""http://some-
server.xxx/xxIdOfTheMonitoringFeature"/>
            </om:NamedValue>
        </om:parameter>
        <om:observedProperty xlink:href="http://some-vocab-server.xxx/ait/O3"/>
        <om:featureOfInterest>
            <gml:FeatureCollection gml:id="FoI1">
                <gml:featureMember xlink:href="http://some-server.xxx/ait/09/AT0098A"/>
            </gml:FeatureCollection>
        </om:featureOfInterest>
```

```
            <om:result>
                <swe:DataArray>
                    <swe:elementCount>
                        <swe:Count>
                            <swe:value>3</swe:value>
                        </swe:Count>
                    </swe:elementCount>
                    <swe:elementType name="Components">
                        <swe:DataRecord>
                            <swe:field name="Time">
                                <swe:Time
definition="http://www.opengis.net/def/property/OGC/0/SamplingTime">
                                    <swe:uom xlink:href="http://www.opengis.net/def/uom/ISO-
8601/0/Gregorian"/>
                                </swe:Time>
                            </swe:field>
                            <swe:field name="feature">
                                <swe:Text definition="urn:ogc:data:feature"/>
                            </swe:field>
                            <swe:field name="O3">
                                <swe:Quantity definition="urn:ogc:def:phenomenon:ait:O3">
                                    <swe:uom code="ppb"/>
                                </swe:Quantity>
                            </swe:field>
                        </swe:DataRecord>
                    </swe:elementType>
                    <swe:encoding>
                        <swe:TextEncoding decimalSeparator="." tokenSeparator=","
blockSeparator="@@"/>
                    </swe:encoding>
                    <swe:values>2008-09-
01T02:00:00+0200,urn:ogc:object:feature:ait:09:AT0098A,28.614536@@2008-09-
01T03:00:00+0200,urn:ogc:object:feature:ait:09:AT0098A,29.157038@@2008-09-
01T05:00:00+0200,urn:ogc:object:feature:ait:09:AT0098A,28.495537@@</swe:values>
                </swe:DataArray>
            </om:result>
        </om:OM_Observation>
    </sos:observationData>
</sos:GetObservationResponse>
```

L.3 GML Coverage Results

The following section shows how a GML Coverage can be provided as an Observation result:

```
<?xml version="1.0" encoding="UTF-8"?>
<sos:GetObservationResponse xmlns:sos="http://www.opengis.net/sos/2.0"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns:om="http://www.opengis.net/om/2.0"
xmlns:gml="http://www.opengis.net/gml/3.2" xmlns:xlink="http://www.w3.org/1999/xlink"
xmlns:swe="http://www.opengis.net/swe/2.0" xmlns:gmlcov="http://www.opengis.net/gmlcov/1.0"
xsi:schemaLocation="http://www.opengis.net/sos/2.0
http://schemas.opengis.net/sos/2.0/sosGetObservation.xsd http://www.opengis.net/gml/3.2
http://schemas.opengis.net/gml/3.2.1/gml.xsd http://www.opengis.net/om/2.0
http://schemas.opengis.net/om/2.0/observation.xsd">
    <sos:observationData>
        <om:OM_Observation gml:id="Obs1">
            <om:phenomenonTime>
                <gml:TimePeriod gml:id="Time1" xsi:type="gml:TimePeriodType">
```

```
                <gml:beginPosition>2008-09-01T02:00:00+0200</gml:beginPosition>
                <gml:endPosition>2008-09-01T05:00:00+0200</gml:endPosition>
            </gml:TimePeriod>
        </om:phenomenonTime>
        <om:resultTime>
            <gml:TimeInstant gml:id="Time2">
                <gml:timePosition>2008-09-01T05:00:00+0200</gml:timePosition>
            </gml:TimeInstant>
        </om:resultTime>
        <om:procedure xlink:href="someRepo/xxx/gravityObservationProcess"/>
        <om:observedProperty xlink:href="someRepo/xxx/observedGravity"/>
        <om:featureOfInterest xlink:href="someRepo/xxx/fOIUrl" xlink:title="scientific study zone yyy"
/>
        <om:result>
            <gmlcov:MultiPointCoverage gml:id="mpc-1">
                <gml:multiPointDomain>
                    <gml:MultiPoint gml:id="mp-1" srsDimension="2" srsName="EPSG:4326">
                        <gml:pointMember>
                            <gml:Point gml:id="stn-001">
                                <gml:pos>654543 76674</gml:pos>
                            </gml:Point>
                        </gml:pointMember>
                        <gml:pointMember>
                            <gml:Point gml:id="stn-002">
                                <gml:pos>654553 76634</gml:pos>
                            </gml:Point>
                        </gml:pointMember>
                        <gml:pointMember>
                            <gml:Point gml:id="stn-003">
                                <gml:pos>654573 76654</gml:pos>
                            </gml:Point>
                        </gml:pointMember>
                        <gml:pointMember>
                            <gml:Point gml:id="stn-004">
                                <gml:pos>654593 76624</gml:pos>
                            </gml:Point>
                        </gml:pointMember>
                        <gml:pointMember>
                            <gml:Point gml:id="stn-005">
                                <gml:pos>654533 76614</gml:pos>
                            </gml:Point>
                        </gml:pointMember>
                    </gml:MultiPoint>
                </gml:multiPointDomain>
                <gml:rangeSet>
                    <gml:DataBlock>
                        <gml:rangeParameters/>
                        <gml:tupleList cs="\n" ts=" ">stn-001 980000 980000 980000 0 0
stn-002 980000 980000 980000 0 0
stn-003 980000 980000 980000 0 0
stn-004 980000 980000 980000 0 0
stn-005 980000 980000 980000 0 0</gml:tupleList>
                    </gml:DataBlock>
                </gml:rangeSet>
                <gmlcov:rangeType>
                    <swe:DataRecord id="drec-1">
                        <swe:field name="identifier">
                            <swe:Text>
                                <swe:identifier/>
                            </swe:Text>
```

```
                        </swe:field>
                        <swe:field name="observedGravity">
                            <swe:Quantity
definition="http://inspire.ec.europa.eu/codeList/GeophPropertyNameValue/gravimetricProperty/observ
edGravity">
                                <swe:uom code="microGal"/>
                            </swe:Quantity>
                        </swe:field>
                        <swe:field name="gravityFreeAirAnomaly">
                            <swe:Quantity
definition="http://inspire.ec.europa.eu/codeList/GeophPropertyNameValue/gravimetricProperty/gravity
FreeAirAnomaly">
                                <swe:uom code="microGal"/>
                            </swe:Quantity>
                        </swe:field>
                        <swe:field name="gravityBouguerAirAnomaly">
                            <swe:Quantity
definition="http://inspire.ec.europa.eu/codeList/GeophPropertyNameValue/gravimetricProperty/gravity
BouguerAnomaly">
                                <swe:uom code="microGal"/>
                            </swe:Quantity>
                        </swe:field>
                        <swe:field name="innerTopoCorrection">
                            <swe:Quantity
definition="http://inspire.ec.europa.eu/codeList/GeophProcessParameterNameValue/gravityProcessP
arameter/topoCorrection/innerTopoCorrection">
                                <swe:uom code="microGal"/>
                            </swe:Quantity>
                        </swe:field>
                        <swe:field name="totalTopoCorrection">
                            <swe:Quantity
definition="http://inspire.ec.europa.eu/codeList/GeophProcessParameterNameValue/gravityProcessP
arameter/topoCorrection/totalTopoCorrection">
                                <swe:uom code="microGal"/>
                            </swe:Quantity>
                        </swe:field>
                    </swe:DataRecord>
                </gmlcov:rangeType>
            </gmlcov:MultiPointCoverage>
        </om:result>
    </om:OM_Observation>
  </sos:observationData>
</sos:GetObservationResponse>
```