

Discussion document:

Good practice for providing (raster) INSPIRE Coverage data and services

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Target audience:

Raster data communities; INSPIRE implementers; INSPIRE data providers from EU Member States; INSPIRE MIG-T.

1. Purpose of this document

This document explains a good practice for the provision of interoperable (raster) INSPIRE Coverage data and services, used for a large list of Annex II and Annex III data themes.

It is the result of a number of activities organised in the scope of the INSPIRE Community Forum (formerly, INSPIRE Thematic Clusters) from October 2014 till nowadays, including related discussion topics in the platform, webinars, workshop, and even an article.

Moreover, it is expected to overcome the current situation of having inconsistent schemas for INSPIRE coverage data which are not properly aligned with the OGC standards which are identified as adopted as default encoding.

This drawback is clearly preventing the interoperable provision of raster data themes in the form of coverage data and related services (WCS / WCPS). Such services have a huge potential for users willing to exploit raster data analytics utilising INSPIRE coverage data, being one of the most interesting and beneficial use cases for big data.

The main objectives of this document are:

- Getting feedback from the community on this functional good practice to align INSPIRE coverages to OGC standards.
- Promote the interoperable schemas identified in Section 5.2 for their widespread use by the thematic communities which have to provide coverage data for INSPIRE purposes.
- Spread the word through INSPIRE MIG-T for the consideration and promotion as an interoperable solution for a large list of INSPIRE themes dealing with (raster) coverage data.

Section 2 introduces in a plain way the concept of coverage, identifies the applicable standards and provides an insight on the current use of coverage data across a large list of different INSPIRE themes from Annex II and Annex III.

Section 3 explains the main issue is affecting the interoperable provision of coverage data in INSPIRE.

Section 4 explains the good practice proposed as a solution to overcome the existing situation, with low efforts to be invested.

Section 5 exemplifies the good practice for INSPIRE Elevation and Orthoimagery themes, while establishing both, the mapping between the elements of such thematic coverages and the OGC CIS 1.0 implementation standard, and the associated sample schemas for its implementation.

Section 6 provides more details about the final purposes of this document and identifies related descriptive resources and discussion topics in the INSPIRE Community Forum platform.

2. Introduction to INSPIRE coverages

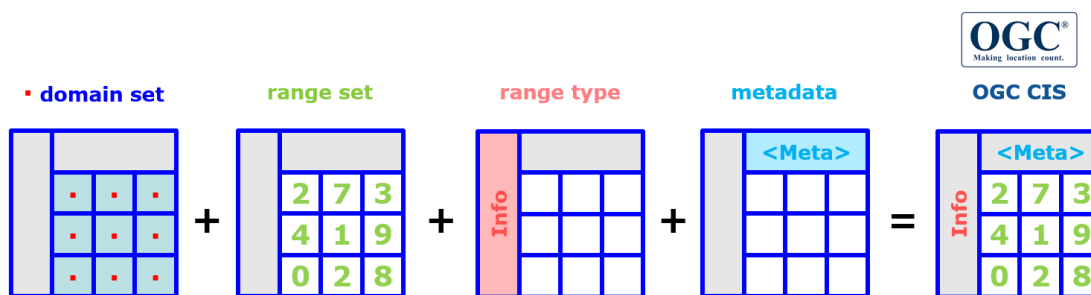
2.1. What is a coverage?

A coverage is a unified paradigm for modelling and encoding raster data of all kind, from 1D sensor timeseries, over 2D raster images, up to spatio-temporal data cubes.

It describes spatio-temporal regular and irregular grids (i.e., multi-dimensional data cubes), point clouds, and general meshes.

In plain words coverage are modelled like a function, composed by the following elements:

- **Domain set**, answering “**at what coordinates can I find values?**” (the domain of the function).
- **Range set**, determining “**what are the values?**” (the image set of the function).
- **Range type**, informing “**which are the basic characteristics of the values?**”. It is utilised to capture the full semantics of the values in the coverage.
- **Optional metadata bucket**, carrying **any additional information** that may be also relevant for users.



The range type of a coverage is also a standardized description based on the SWE (Sensor Web Enablement) Common (<http://www.opengeospatial.org/standards/swe>) concepts.

This allows sensor data to be transformed into coverages without information loss, thereby enabling seamless service chains from upstream data acquisition (e.g., through OGC SOS) to downstream analysis-ready user services (such as OGC WMS, WCS, and WCPS).

Such coverages can be represented in a variety of shapes – including tilings, coordinate/value pair lists – and formats - such as GML, JSON, RDF, a variety of binary encodings, as well as “containers” with mixed encodings. Hence, tools can request coverages in their favourite format from a server.

2.2. Coverage standards

Coverages are fully standardized by the OGC (Open Geospatial Consortium):

- At abstract, conceptual level, in [OGC Abstract Topic 6](#) which is identical to [ISO 19123](#).
- At concrete, interoperable level in the **OGC Coverage Implementation Schema (CIS)**, which is adopted by ISO as [19123-2](#).

Several versions of the OGC Coverage Implementation Schema (CIS) exist:

CIS 1.0, formerly known as “GML 3.2.1 Application Schema – Coverages” (GMLCOV).

CIS 1.1, which provides a comprehensive, more consistent schema for grid coverages. It is backwards compatible with its predecessor, CIS 1.0.

Find here [more details on coverage standardisation](#).

2.3. Use of coverages in INSPIRE

Coverages are widely used in different thematic domains in the scope of the INSPIRE Directive:

- Annex II: Elevation (EL), Land cover (LC), Orthoimagery (OI), Geology (GE).
- Annex III: Soil (SO), Land use (LU), Natural risk zones (NZ), Environmental Monitoring Facilities (EF), Atmospheric conditions (AC), Meteorological geographical features (MF), Oceanographic geographical features (OF), Energy resources (ER), Species Distribution (SD).

However, two different approaches are used by INSPIRE themes to serve coverage data to the user:

1. WCS view: Coverages are considered as features

INSPIRE Feature Types in these themes are based on Coverage Classes.

Regular or irregular grids are used by the WCS view INSPIRE themes.



• Regular grids:

- Elevation (EL)
- Land cover (LC)
- Orthoimagery (OI)
- Soil (SO)
- Energy resources (ER).
- Species distribution (SD)
- Application schema deprecated.

• Regular or Irregular grids:

- Natural risk zones (NZ)
- Geology (GE).

Default coverage encoding for the mentioned themes is based on CIS 1.0.

2. SOS view: Coverages are considered as observation results

Regular or irregular grids are used by the SOS view INSPIRE themes.



• Regular or irregular grids

- Environmental monitoring facilities (EF)
- Atmospheric conditions (AC)
- Meteorological geographic features (MF)
- Oceanographic geographic features (OF)
- Geology (GE)
- Provided as discrete observation coverages, i.e. gridded data specialized observation types applying the ISO 19156:2011 (O&M), following *INSPIRE D2.9 v3.0*

3. Which is the main issue about INSPIRE coverages?

The INSPIRE data models from the technical guidelines of the different themes were drafted at conceptual level. For this reason, it was necessary to specify concrete rules for the delivery and encoding of data, either as part of the own data specifications or in separate INSPIRE guidance documents (e.g. [INSPIRE D2.7 – Guidelines for the encoding of spatial data v3.3](#)).

This approach was also applied to the INSPIRE application schemas which serve to model coverage data across different themes, by selecting CIS 1.0 (nicknamed GMLCOV in the past) as default encoding rule for coverage data.

Despite of it the rules specified were not complete enough to assure the interoperability of data (coverages) and related services due to:

- Lack of clarity of the standards for implementing coverages existing at that point of time (GML 3.2.1, GML 3.3, CIS 1.0 - See [coverage standardisation](#)).
- Possible misinterpretation (not ample experience on them).
- Immaturity and inconsistencies of the standards in place.

As a result, a number of INSPIRE-defined properties were identified by the Thematic Working Groups (TWGs) to be necessary or appropriate in the context of the European spatial data infrastructure. They were appended to each of the theme-specific coverage feature types in the conceptual data models.

When deriving the corresponding INSPIRE application schemas from the conceptual data models, such properties were also appended as part of the INSPIRE coverage elements to be encoded, adding contents not foreseen in the OGC CIS 1.0 implementation standard.

All these theme-specific properties constitute a deviation from the OGC CIS 1.0 standard, because they neither map to any existing GML nor CIS properties.

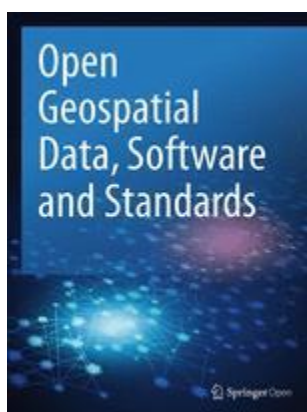
From now on we refer to such additional contents as INSPIRE extensions.

Such extension shall be removed from the INSPIRE application schemas for coverage data.

See graphically the Good Practice Proposal in the next figure.

To find details about the preliminary analysis with INSPIRE coverages, including other minor issues identified, please refer to the **article “INSPIRE coverages: an analysis and some suggestions”**.

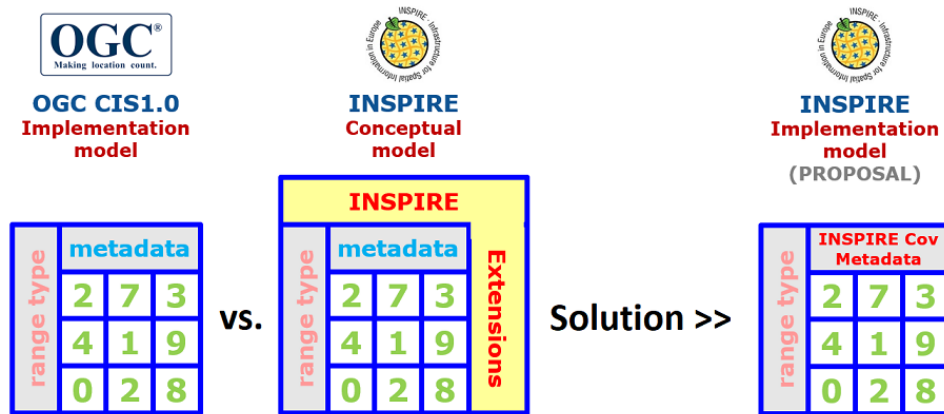
<https://link.springer.com/article/10.1186/s40965-019-0059-x>



4. Good Practice: Proposal for an interoperable solution

A functional solution to align INSPIRE coverages to OGC standards, is amending in a simple way the INSPIRE XSD coverage schemas by adding the INSPIRE extensions as coverage metadata, included within an OGC compliant CIS 1.0 coverage.

In other words, **INSPIRE extensions may be easily provided within the coverage metadata bucket**, being one of the components of an OGC coverage as described earlier - See below.



A coverage service for various (raster data) INSPIRE themes has been setup to overcome these issues as a result of the [related activities](#) performed in the scope of the INSPIRE Community Forum (Thematic Clusters) during the last years, particularly based on the results from the [Workshop “Feel the power of INSPIRE WCS / WCPS in your hands”](#) organised in the INSPIRE Helsinki 2019 Technical Conference:

“INSPIRE Coverages Demystified”: <https://inspire.rasdaman.org/>

The demo service allows the user to play with different service requests to get INSPIRE coverage data and metadata, analyse and combine different data layers (cross-theme fusion), download and present the final results.

It is specially designed to demonstrate use of coverages and WCS/WCPS for several INSPIRE themes: Elevation, Orthoimagery and Land cover - The service is powered by the [rasdaman WCS reference implementation](#) and offers sample data from a regional data provider ([Institut Cartogràfic i Geològic de Catalunya, ICGC](#)).

The objectives are to:

- Experience the potential of these technologies.
- Fully-understand the main benefits of integrating them within their daily geospatial businesses and analytical tasks.
- Get feedback from the community on this functional good practice to align INSPIRE coverages to OGC standards, by amending in a simple, OGC compliant way the INSPIRE XSD coverage schemas (as INSPIRE coverage metadata).

5. Example of application for INSPIRE Themes: Elevation & Orthoimagery

For the purpose of exemplifying the present good practice the Elevation and Orthoimagery themes have been selected.

Section 5.1 defines the mapping between the elements composing an INSPIRE Elevation / Orthoimage coverage (according the current technical guidelines of both themes¹), and the elements expected in the OGC CIS 1.0 implementation schema.

¹ D2.8.II.1 INSPIRE Data Specification on Elevation – Technical Guidelines v3.0
D2.8.II.3 INSPIRE Data Specification on Orthoimagery – Technical Guidelines v3.0

Those INSPIRE elements without any matching, or without an exact matching, are identified as ‘INSPIRE Extensions’.

5.1. Mappings

The table below describes the mapping of Elevation and Orthoimagery coverage elements to OGC CIS 1.0 the schema.

INSPIRE Conceptual data model		Mapping to OGC CIS v1.0	
Coverage element: type [cardinality]	<<stereotype>>	Element type	CIS (gmlcov;) / GML element (gml:)
ElevationGridCoverage (type RectifiedGridCoverage as defined in D2.10.2 Error! Reference source not found.)	<<featureType>>	Spatial object	gmlcov:RectifiedGridCoverage
OrthoimageCoverage (type RectifiedGridCoverage as defined in D2.10.2 Error! Reference source not found.)	<<featureType>>	Spatial object	
domainSet: Any [1] (type constrained to CV_RectifiedGrid)	-	Attribute	gmlcov:RectifiedGridCoverage.domainSet [1] (type gml:RectifiedGrid)
rangeSet: Any [0..*] (type duly constrained in each theme; represents each of the coverage values)	-	Attribute	gmlcov:RectifiedGridCoverage.rangeSet [1] (type gml:RangeSet; represents the set of coverage values)
rangeType: RecordType [1]	-	Attribute	gmlcov:RectifiedGridCoverage.rangeType [1] (type swe:DataRecord)
metadata: Any [0..*]	-	Attribute	gmlcov:Coverage.metadata: Any [0..*]
inspireId: Identifier [1]	-	Attribute	gml:id (coverage identifier) NOTE: It is also needed as unique identifier within the INSPIRE Coverage metadata.
domainExtent: EX_Extent [1..*]	-	Attribute	Not exactly matched (INSPIRE Extension) . NOTE: Similar to gml:boundedBy / gml:Envelope / gml:EnvelopeWithTimePeriod
beginLifespanVersion: DateTime [1]	<<voidable>>	Attribute	Not matched (INSPIRE Extension) .
endLifespanVersion: DateTime [1] [0..1] (Cardinality [1] in EL; [0..1] in OI)	<<voidable>>	Attribute	Not matched (INSPIRE Extension) .
contributingElevationGridCoverage [0..*]	-	Aggregation relationship	Not matched (INSPIRE Extension) .
contributingOrthoimageCoverage [0..*]	-	Aggregation relationship	
ElevationGridCoverageAggregation	-	Association class	Not matched (INSPIRE Extension) .
OrthoimageAggregation	-	Association class	
propertyType: ElevationPropertyTypeValue [1]	-	Attribute	Not matched (INSPIRE Extension) .
surfaceType: SurfaceTypeValue [1]	-	Attribute	Not matched (INSPIRE Extension) .
interpolationType: InterpolationMethod [1]	-	Attribute	Not matched (INSPIRE Extension) .
footprint: GM_MultiSurface [1]	<<voidable>>	Attribute	Not matched (INSPIRE Extension) .
name: CharacterString [0..1]	<<voidable>>	Attribute	Not matched (INSPIRE Extension) .
phenomenonTime: TM_Period [0..1]	<<voidable>>	Attribute	Not matched (INSPIRE Extension) .
mosaicElement [0..*]	<<voidable>>	Association relationship	Not matched (INSPIRE Extension) .

Legend:



Elevation theme



Orthoimagery theme



Both themes

5.2. Proposed amended schemas

As explained in the Section 4, this discussion document proposes to:

1. Directly adopt OGC CIS 1.0 coverage implementation schema as default encoding for INSPIRE coverage data models:

<http://schemas.opengis.net/cis/1.0/coverage.xsd>

2. Define INSPIRE coverage metadata schemas in order to provide all the additional elements required by the Directive (INSPIRE extensions).

The draft proposed Elevation and Orthoimagery schemas for providing INSPIRE coverage metadata based on the present good practice are accessible through the next links:

- Elevation:

<https://schema.datacove.eu/ElevationGridCoverageMetadata.xsd>

- Orthoimagery:

<https://schema.datacove.eu/OrthoimageryMetadata.xsd>

NOTE: Despite not being related to the example themes showed in this discussion document, there is also available a proposed schema for the **Land cover** theme:

<http://test.datacove.eu/LandCoverRasterMDExt.xsd>

The previous sample schemas should be revised with a minimum effort in order check consistency and completeness of the all the properties included in the INSPIRE Implementing Rule for the Interoperability of Data sets and Services for the above-mentioned themes.

Ideally JRC should be hosting the final schemas for their custody and usage in the long term, in case of adopting the present good practice.

6. Next steps

The aim of this discussion document is to get feedback from the community on this functional good practice to align INSPIRE coverages to OGC standards.

Furthermore, it is envisaged to promote the interoperable schemas identified in Section 5.2 for their widespread use by thematic communities having to provide coverage data for INSPIRE purposes.

Related contents have been published in the Software & Tools group of the INSPIRE Community Forum for this purpose:

- Dedicated page: HTML presentation of the present discussion document on the Web:
<https://inspire.ec.europa.eu/forum/pages/view/265454/an-effective-good-practice-to-boost-interoperable-provision-of-raster-inspire-coverage-data-and-services>
- Discussion topic: Open for getting feedback:
<https://inspire.ec.europa.eu/forum/discussion/view/265095/inspire-coverages-demo-service>

Finally, it is expected to be submitted to INSPIRE MIG-T for its consideration and promotion as an interoperable solution for a large list of INSPIRE themes dealing with (raster) coverage data.

Once proved evidence of enough and mature successful implementations, the content of this document will be documented in an INSPIRE Good Practice in order to claim its potential endorsement by INSPIRE MIG-T.

In this case, a number of proposals for change to the relevant technical guidelines (and the Implementing Rules, if needed) will be formulated to update the INSPIRE framework documents affected.