



Monitoring the FAIRness of geospatial data: Lessons learnt from the European Union

Marco Minghini, Jordi Escriu, Alexander Kotsev

European Commission, Joint Research Centre (JRC)



Introduction

Introduction – Problem statement

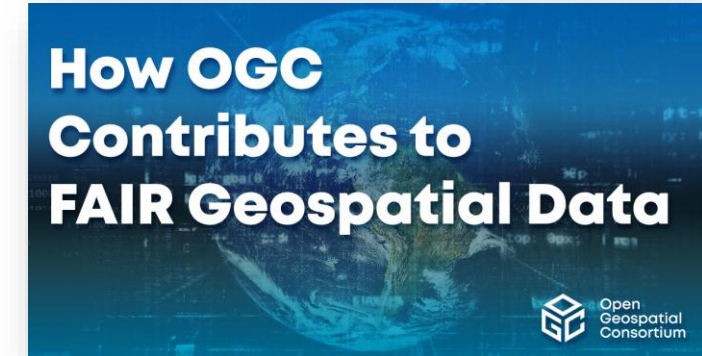
- **Geospatial data sharing** has profoundly changed over the last decades
 - from traditional SDIs to multi-faceted **data sharing ecosystems** ^[1,2]
 - (big) **data sources**: from research, EO, IoT, crowdsourcing, AI/ML
 - **technology & infrastructures**: cloud, edge & fog; standards; AI/ML models
 - **actors**: private companies & citizens
 - **legislation** to open data, improve data sharing, protect privacy
 - **business models** & governance structures

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 - **legislation** to open data, improve data sharing, protect privacy
 - **business models** & governance structures
- However, geospatial data is often difficult to access and use – issues are
 - **technical**: interoperability, use of proprietary technologies, vendor lock-in, etc.
 - **legal**: copyright, licensing, legislatively-driven constraints, etc.
 - **governance**: silos, gatekeepers from big commercial actors, etc.

Introduction – Problem statement

- FAIR (Findable, Accessible, Interoperable & Reusable) principles help mitigate this challenge
 - a cornerstone in research, standardisation & data sharing at all scales^[3,4,5]

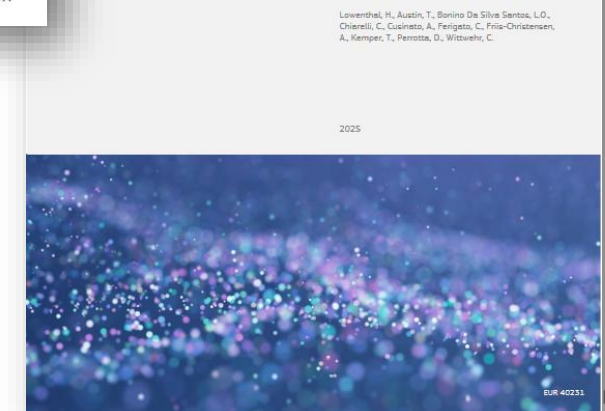


Open science across Horizon Europe

Legal provisions in the grant agreements will strengthen open access rights and obligations for beneficiaries. Horizon Europe will require immediate open access to all scientific publications and responsible research data management so that data are **Findable, Accessible, Interoperable and Re-usable (FAIR)**. Data will be made 'as open as possible, but will be allowed to stay as closed as necessary', safeguarding legitimate interests or constraints. However access to research outputs shall be provided for third parties to be able to verify or validate publications.

The **criteria for evaluating research proposals** under Horizon

JRC FAIR Data Guidelines



Introduction – Problem statement

- **Public sector** remains an important provider and user of geospatial data
 - ensuring delivery of **high-quality**, **trustworthy** & authoritative data
 - supporting **transparency**, **accountability** & informed **decision making**
- **FAIRness** of public geospatial data infrastructures is the ultimate objective
- Progress towards FAIRness is measured through various **KPIs** – e.g.
 - Canadian Geospatial Data Infrastructure (CGDI) framework^[6]
 - United States (US) Geospatial Data Act's data quality and accessibility metrics^[7]
 - EU INSPIRE Directive^[8] and Open Data Directive^[9]

Objective

- Focus on the **EU context** 
- Reflect on **6 years of operational experience** in monitoring the FAIRness of the EU public geospatial data infrastructure
 - relevant legislation and monitoring requirements
 - approach and KPIs adopted
- Distill **lessons learnt** from the outcomes
 - relevant for other legislatively-driven initiatives

EU legal context & FAIRness monitoring

INSPIRE Directive (2007)

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)

- Aimed to **unlock public sector geospatial data** & facilitate cross-border sharing
- Led to the establishment of a FAIR **EU public geospatial data infrastructure**
 - data discoverability (**metadata**), accessibility (**network services**) & interoperability (**data models**)
- The **largest** geospatial data sharing effort ever!
- **Evaluation** in 2022 triggered a possible **revision**, currently ongoing

<https://eur-lex.europa.eu/eli/dir/2007/2>

INSPIRE infrastructure

European Commission

INSPIRE Geoportal

Home | Priority Datasets | High-Value Datasets | Thematic Data | Find out more

INSPIRE Datasets - EU & EFTA Country overview

Geoportal Dataset Statistics

132092 Metadata records

101404 Downloadable Datasets

103532 Viewable Datasets

Spatial scope coverage:

☐ National ☐ Regional

Select a country

Austria	1290	1279	541	Greece	45	45	44	Netherlands	239	205	215
Belgium	813	557	500	Hungary	78	87	55	Norway	142	49	22
Bulgaria	107	115	129	Iceland	108	62	85	Poland	172	129	123
Croatia	145	98	127	Ireland	84	72	61	Portugal	345	223	222
Cyprus	42	42	41	Italy	8519	2809	4543	Romania	124	51	48
Czech Republic	90	84	87	Latvia	158	87	94	Slovakia	147	138	142
Denmark	197	144	134	Liechtenstein	88	38	58	Slovenia	81	40	42
Estonia	92	73	74	Lithuania	103	102	98	Spain	390	382	385
Finland	438	207	253	Luxembourg	316	314	293	Sweden	250	225	231
France	207	119	141	Malta	162	151	150	EUROSTAT	30	30	30
Germany	110880	93400	94324	Moldova	189	4	95				

European Commission

INSPIRE Reference Validator

Home | Test selection | Test reports | Get support | More on the INSPIRE Reference Validator

Configure your test

Select the INSPIRE resource you would like to test

☒ Metadata

☐ View Service

☐ Download Service

☐ Discovery Service

☐ Data set

Select the type of metadata record(s) to be tested

☒ Data sets and data set series

☐ Network Service

☐ Spatial Data Service

Advanced options

Provide the resource to test

Select the input type and upload or link the resource

Select an XML file or a ZIP file containing one or multiple XML files. The Maximum size of the uploaded file is 50 MB. The upload starts immediately after selecting the files. The 'Start' button is unlocked when the upload has been successfully completed.

File upload

Upload file *

Maximum size is 50 MB.

Encrypted documents and those containing macros are not accepted.

Replace files

Dataset_metadata_2_0_example.xml (41.2 kB - xml)

Provide a label for your test report (optional)

Your test report will appear with the label below; edit the text if you wish to change it.

Test run on 09:20 - 07.07.2025 with test suite Conformance Class 8: INSPIRE data sets and data set

Start test

European Commission

English

Search

European Commission > INSPIRE >

INSPIRE registry

URI: <http://inspire.ec.europa.eu/registry>

Label: **INSPIRE registry**

Content summary: The INSPIRE infrastructure involves a number of items, which require clear descriptions and the possibility to be referenced through unique identifiers. Examples for such items include INSPIRE themes, code lists, application schemas or discovery services. Registers provide a means to assign identifiers to items and their labels, definitions and descriptions (in different languages). The INSPIRE registry provides a central access point to a number of centrally managed INSPIRE registers. The content of these registers are based on the INSPIRE Directive, Implementing Rules and Technical Guidelines.

Registry Manager: European Commission, Joint Research Centre

Insert date: 2013-05-28 15:30 PM UTC

Available formats: [XML Registry](#) [XML ISO 19135](#) [RDF/XML](#) [JSON](#) [CSV](#) [ATOM](#) [ROR](#)

Available items

Show 25 entries Showing 1 to 11 of 11 entries

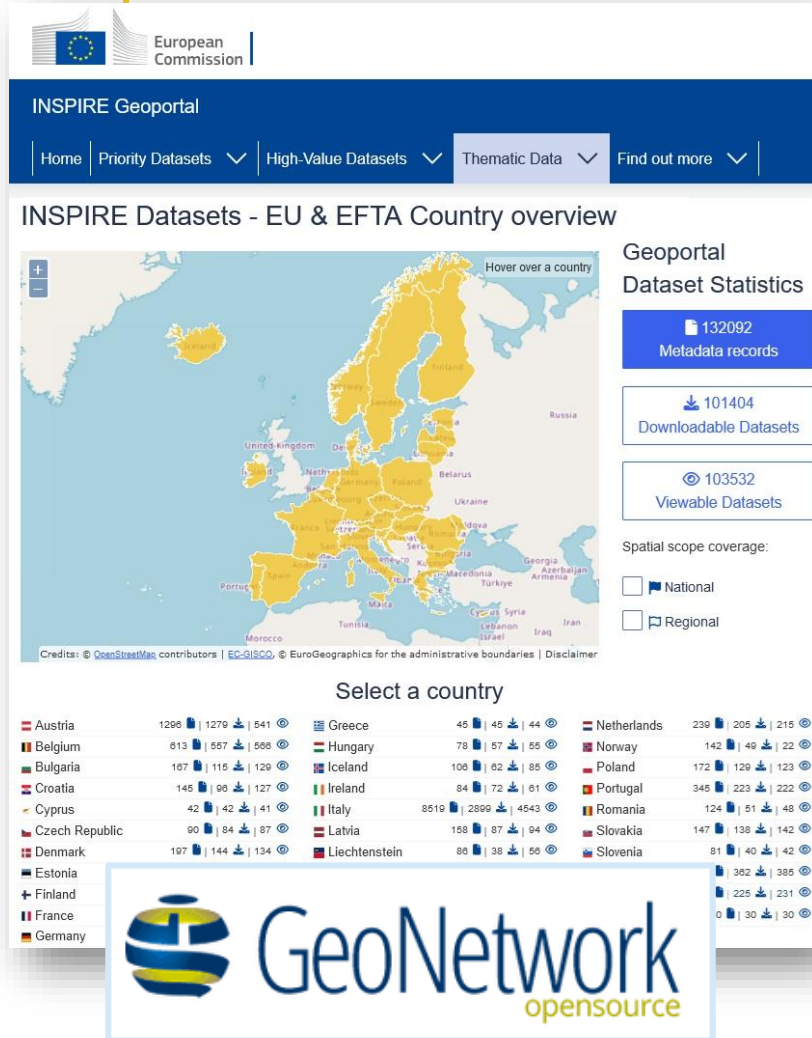
Label
INSPIRE application schema register
INSPIRE code list register
INSPIRE coordinate reference systems register
INSPIRE enumeration register
INSPIRE feature concept dictionary
INSPIRE glossary
INSPIRE layer register
INSPIRE media-types register
INSPIRE metadata code list register
INSPIRE reference document register
INSPIRE theme register

<https://inspire-geoportal.ec.europa.eu>

<https://inspire.ec.europa.eu/validator>

<https://inspire.ec.europa.eu/registry>

INSPIRE infrastructure (open source)



European Commission

INSPIRE Geoportal

Home | Priority Datasets | High-Value Datasets | Thematic Data | Find out more

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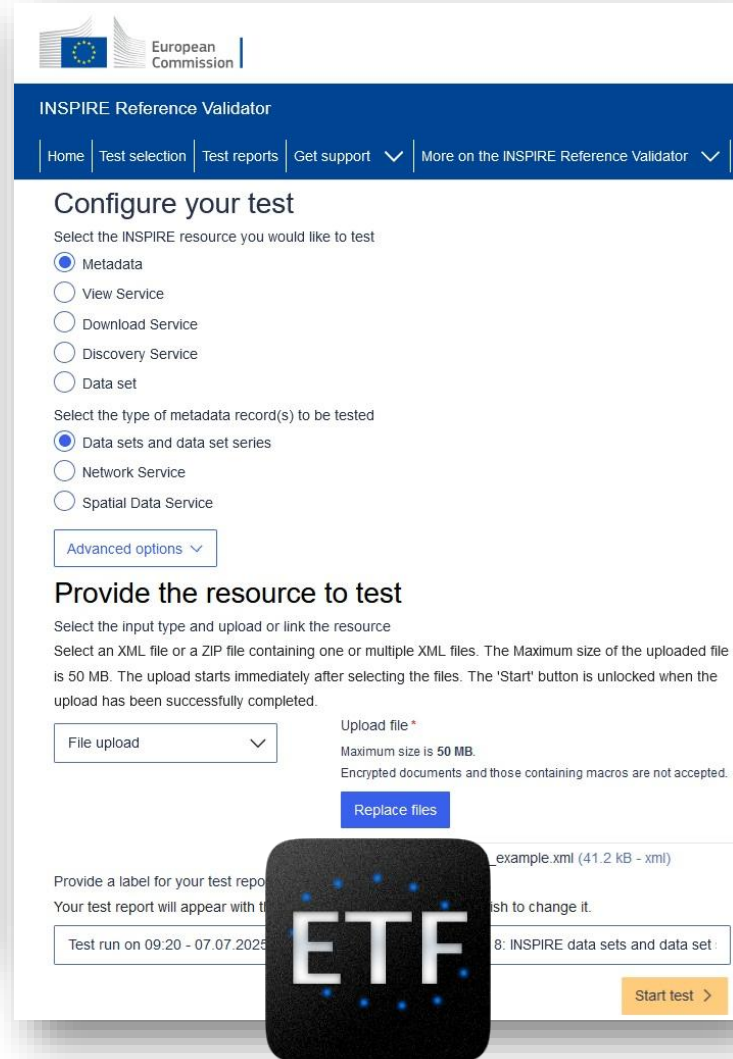
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GeoNetwork opensource

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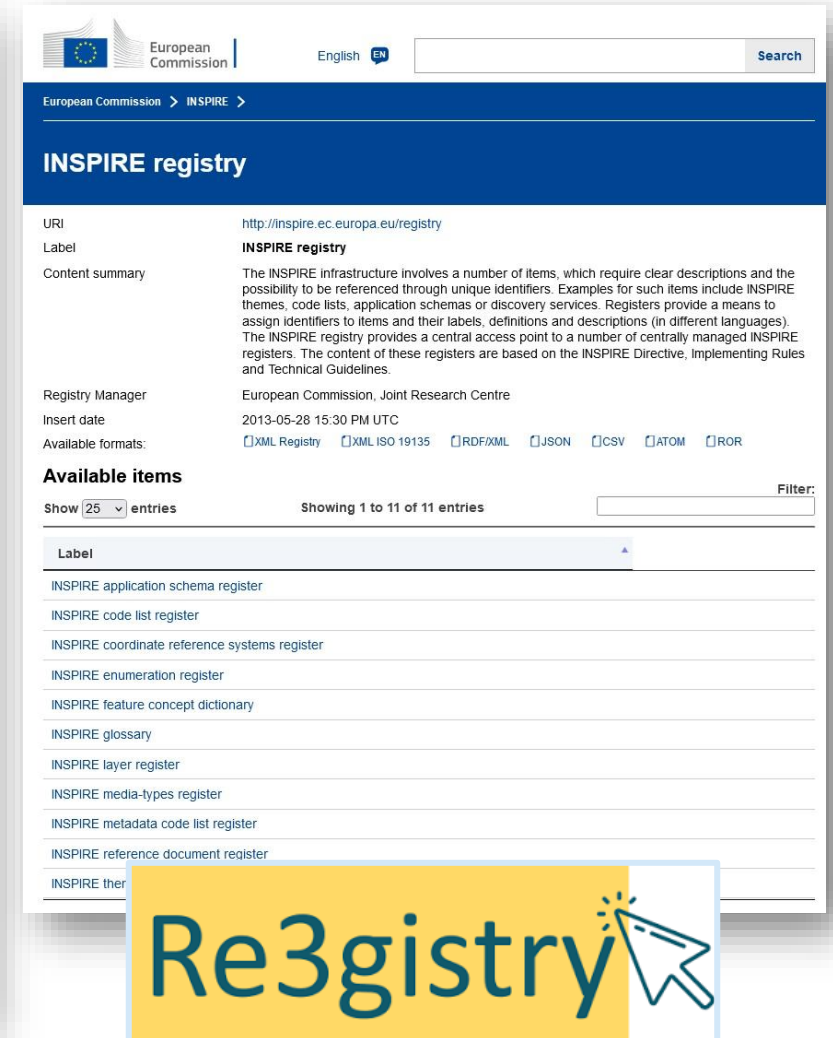
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8: INSPIRE data sets and data set

Start test

ETF

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European Commission

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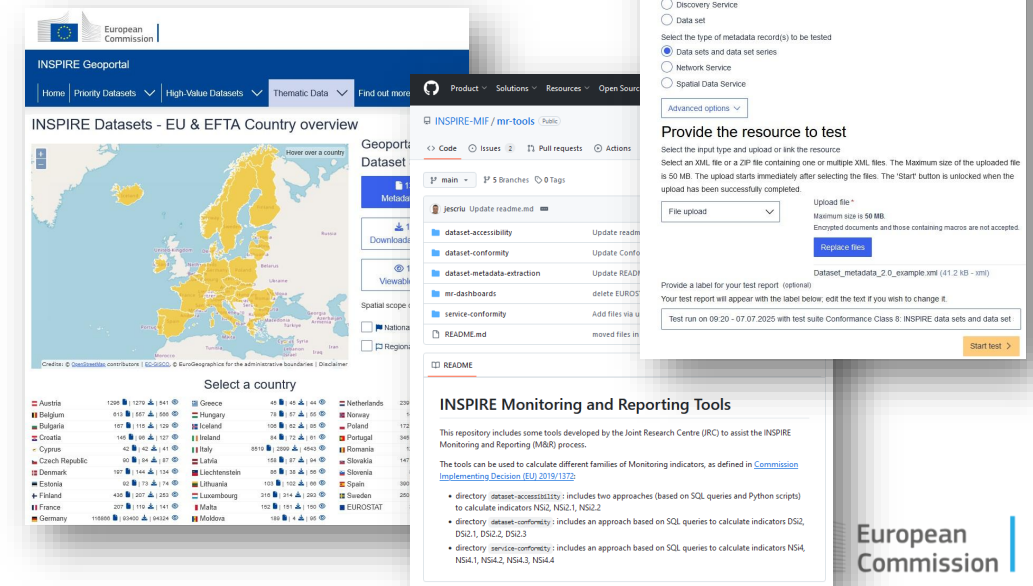
Monitoring – INSPIRE Directive

- Process rooted in the very nature of EU legislation
 - certification of compliance from Member States & evidence for possible infringements
 - opportunity for Member States to strengthen cooperation at the national level and enhance accountability
- Monitoring rules currently in place were defined in 2019^[10]
- Automated calculation of 19 KPIs divided in 5 categories^[11]
 - availability of spatial data and services
 - conformity of metadata
 - conformity of spatial data sets
 - accessibility of spatial data sets
 - conformity of network services

COMMISSION IMPLEMENTING DECISION (EU) 2019/1372
of 19 August 2019
implementing Directive 2007/2/EC of the European Parliament and of the Council as regards
monitoring and reporting

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 - conformity of spatial data sets
 - accessibility of spatial data sets
 - conformity of network services
- Fully **automated process** based on the INSPIRE infrastructure



Open Data Directive (2019) & Implementing Act on high-value datasets (2023)

- The Open Data Directive ^[9] defined **high-value datasets** (HVD)
 - datasets the **re-use** of which is associated with important **socio-economic benefits**
- To be made available
 - for **free**, under **open access** licenses
 - in **machine-readable formats**, via **APIs** and (when relevant) as a bulk download
- Thematic categories of HVD

Geospatial

*Earth observation
and environment*

Meteorological

Statistics

*Companies and
company
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Mobility

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**geospatial
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**geospatial
datasets**

- The Implementing Act^[12] defines
 - the **list of high-value datasets** for each thematic category
 - the **requirements** for their provision:
 - license (**CC BY 4.0**, **CC0** or any equivalent or less restrictive license)
 - key attributes, formats, metadata, granularity, etc.

Reporting – Open Data Directive

Reporting

1. By 2 years after entry into force of this Implementing Regulation Member States shall provide the Commission with a report on the measures they have carried out to implement this Implementing Regulation. Where appropriate, the information under paragraph 3 can be provided through references to relevant metadata.
2. Each Member State shall provide an updated version of the report upon the request of the Commission which should be made every 2 years.
3. The report shall contain the following information:
 - (a) a list of specific datasets at Member State level (and, where relevant, subnational level) corresponding to the description of each high-value dataset in the Annex to this Regulation and with online reference to metadata that follow existing standards, such as a single register or open data catalogue;
 - (b) persistent link to the licensing conditions applicable to the re-use of high-value datasets listed in the Annex to this Regulation, per dataset referred to in point a);
 - (c) persistent link to the APIs ensuring access to the high-value datasets listed in the Annex to this Regulation, per dataset referred to in point a);
 - (d) where available, guidance documents issued by the Member State on publishing and reusing their high-value datasets;
 - (e) where available, the existence of data protection impact assessments carried out in accordance with Article 35 of Regulation (EU) 2016/679;
 - (f) the number of public sector bodies exempted in accordance with Article 14(5) of Directive (EU) 2019/1024.

- No monitoring KPIs defined in the legislation, only a reporting obligation
 - every two years, first one was in February 2025
 - still focused on the FAIRness of implementation

Results & Lessons learnt

General considerations

- Monitoring results – INSPIRE Directive (2019-2024)
 - slow but continuous improvement of KPI values
 - currently a well-established process
- Reporting results (still under processing) – Open Data Directive (2025)
 - not all Member States submitted a report
 - heterogeneous picture – geospatial high-value datasets not in all cases coinciding with those reported under INSPIRE
 - legal, organisational & technical issues
 - partial availability of established approaches and guidelines

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Policy implementation, especially for public sector-driven initiatives, takes time!

Monitoring strategy

- The way chosen to monitor a policy initiative will **influence its development**
- Implementers **tuned their infrastructures** to maximise the KPI values
 - example: to maximise the fraction of conformant metadata, in some cases they simply decreased the total number of metadata!

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High-values of KPIs (i.e. of FAIRness) do not necessarily mean quality!

- KPIs do not measure whether all resources have been shared
- KPIs do not measure the *content* of data, e.g. no topology/**quality checks**

Monitoring strategy

- KPIs should also measure the **value**/fitness for use for user needs
 - just counting data does not make sense
 - depending on the cases, different/**partial levels of FAIRness** may be enough
 - incorporation of **CARE** (**C**ollective **B**enefit, **A**uthority to **C**ontrol, **R**esponsibility and **E**thics) principles^[13] can be incorporated

Move from provider-centric to user-centric KPIs!

Monitoring strategy

- The values of some conformity KPIs are based on **self-declarations** by implementers
 - self-declarations were demonstrated to be largely unreliable^[14]

KPIs based on self-declarations should be avoided!

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- Legislation requires monitoring to happen at predefined moments, e.g. for INSPIRE on 15 December every year
 - improvement actions at the national level were **concentrated** in the period immediately preceding the deadline

Move from discrete to continuous monitoring!

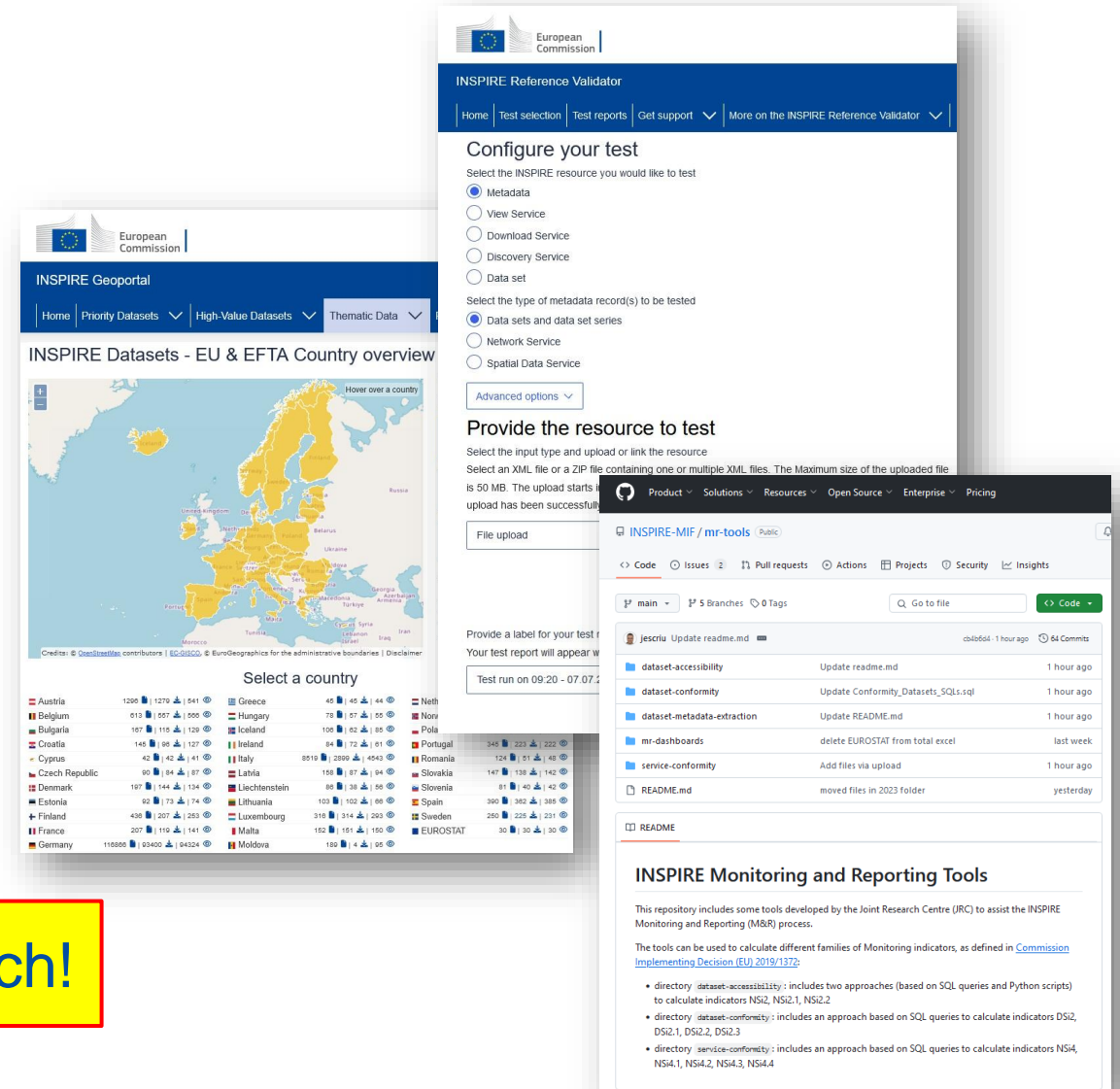
Technical & technological aspects

- Calculation of KPIs has changed over the years to take into account **new developments**, e.g.
 - GeoPackage & GeoJSON as valid data encodings
 - OGC API - Features as a valid data sharing API

Design a flexible monitoring approach that can accommodate novelties

Technical & technological aspects

- Monitoring is based on a fully **automated** and transparent process
- Software stack entirely based on **open source** components
 - clear **documentation** and **release plans** to enable early testing/preparation
 - **objectivity, transparency & reproducibility** of results
 - the validation tool brought **legal certainty** to the process



The image displays three screenshots related to the INSPIRE Monitoring and Reporting Tools:

- INSPIRE Geoportal:** A map of Europe showing the distribution of INSPIRE Datasets across EU & EFTA countries. Below the map is a table titled "Select a country" with columns for country, number of datasets, and a list of dataset names. The table includes data for Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Moldova, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, and EUROSTAT.
- INSPIRE Reference Validator:** A web interface for configuring a test. It includes sections for "Configure your test" (selecting the resource type and metadata record(s)), "Provide the resource to test" (selecting the input type and uploading a file), and "Advanced options".
- INSPIRE-MIF / mif-tools:** A GitHub repository page showing the project's structure, including a README file, a dataset-accessibility directory, a dataset-conformity directory, a dataset-metadata-extraction directory, a mr-dashboards directory, a service-conformity directory, and a README.md file. The repository is managed by jescrli and has 5 branches and 0 tags.

Adopt an open-by-design technical approach!

Community and governance

- The ultimate success of monitoring relies on establishing a continuous **dialogue** and a **trust** relationship with the relevant community
 - setup of clear **governance** structures
 - provide scientifically sound **guidance** on KPIs calculation, **interpretation** of results & **feedback** on improvement areas
 - if engaged, the community **contributes back** by improving the infrastructure



A technical infrastructure is only as good as the social infrastructure underpinning it!

Conclusions

Conclusions




- Analysis of processes for **monitoring FAIRness** of public geospatial data infrastructures, with examples from the EU
 - analysis of positive & negatives, deriving **lessons**
 - formulation of actionable **improvement proposals**, do's & don'ts
 - relevance to a broad range of data sharing initiatives
- Making infrastructures FAIR should not be the goal but **a means to an end**
 - address user demands, support decision-making and generate societal **value**
- A wish-list that research can help achieve:
 - choose *good* KPIs beyond FAIRness, capturing **data usage/value** derived from use
 - use available technology (AI, APIs, etc.) to shift monitoring from time-bounded activities to **real-time processes**

Want to know more?

- Check the paper

The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XLVIII-4/W13-2025
FOSS4G (Free and Open Source Software for Geospatial) Europe 2025 – Academic Track, 14–20 July 2025, Mostar, Bosnia-Herzegovina

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¹ European Commission, Joint Research Centre (JRC), Ispra, Italy – (marco.minghini, jordi.escriu, alexander.kotsev)@ec.europa.eu

Keywords: Data sharing, Data-driven, Geospatial, Monitoring, Spatial Data Infrastructures, Key Performance Indicators.

Abstract

The Findable, Accessible, Interoperable and Reusable (FAIR) principles were introduced to mitigate challenges in discovering, accessing and ultimately reusing data. They still represent the backbone of current, public sector-driven geospatial data infrastructures worldwide, and Key Performance Indicators (KPIs) are used to measure the progress towards their implementation. This work reflects on the experience of the European Union (EU) geospatial data infrastructure, driven by the INSPIRE and the Open Data Directive requirements. Analysing the results of the monitoring process in the last six years, we draw a number of lessons. First and foremost, the way in which KPIs are defined steers the development of an infrastructure against specific directions, and maximising the KPIs used to measure the FAIRness is not enough. A shift would be needed to more user-centric monitoring approaches, which originate from user needs and assess the actual value generated from data reuse. The analysis also demonstrated the importance of employing automated, transparent and reproducible monitoring processes powered by open source tools, as well as the need to define an inclusive governance approach grounded on a continuous involvement, dialogue and trust with the affected stakeholders.

<https://isprs-archives.copernicus.org/articles/XLVIII-4-W13-2025/179/2025/isprs-archives-XLVIII-4-W13-2025-179-2025.pdf>

- Don't miss my (related) talk tomorrow!

12:00

PM

30min

Unlocking the value of
geospatial data: early insights
from the EU Open Data
Directive



Marco Minghini

FOSS4G 'Made in Europe'

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- [5] How OGC Contributes to FAIR Geospatial Data, 2023. <https://www.ogc.org/blog-article/how-ogc-contributes-to-fair-geospatial-data> (accessed 11 July 2025)
- [6] CGDI, 2001. CGDI Framework Data Definition: A Working Definition Prepared by the GeoConnections Framework Data Node. *Geomatica* 55(2), 192-207. <https://doi.org/10.5623/geomat-2001-0023>
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Thank you!



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