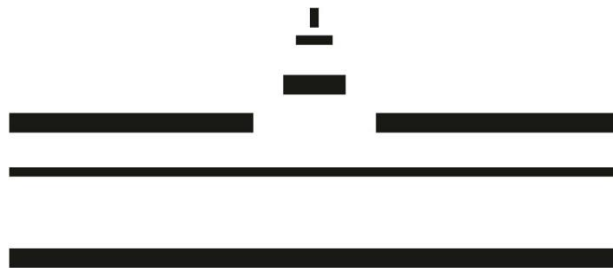


ATOM-FEEDS FOR INSPIRE -

Perspectives and Solutions for
INSPIRE Download Services in NRW



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Masterthesis

in

Geoinformatics

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Plagiatserklärung der / des Studierenden

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ATOM-Feeds for INSPIRE – Perspectives and Solutions for Download Services in NRW

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Abstract

One proposed solution for providing Download Services for INSPIRE is using pre-defined ATOM-Feeds. Up to now the realization of ATOM-Feeds in NRW is still at the beginning. This master thesis will investigate possible solutions in order to help developing a methodology for the implementation of pre-defined INSPIRE Download Services in NRW. Following research questions form the basis of the thesis:

- What implementing alternatives for automatic generation of ATOM-Feeds based on ISO metadata exist?
- How do the identified solutions suit in order to fulfil the requirements of NRW?

In the first step required technologies are introduced, including ATOM, OpenSearch and OGC standards. Thereafter these technologies are analyzed in the context of INSPIRE. Connections will be explained and the role Service-Metadata and Data-Service-Coupling will be investigated.

Based on that foundation the thesis defines specific requirements. On the one hand technical requirements for pre-defined Download Service ATOM-Feed. On the other hand the general requirements in NRW. The next step is an analysis of existing software solutions for the implementation of ATOM-Feeds. The combination of requirements and software is the basis for the development of realization alternatives. At this point a research takes place that investigates the applicability of the software tools in order to fulfil the requirements. Finally the results will be evaluated and discussed.

This thesis is a conceptional work. That means it does not develop new software solutions, but in detail analyses existing solutions and technologies. The goal is finding strategies and concepts for the implementation of INSPIRE ATOM-Feeds in NRW.

Keywords

INSPIRE, Download Service, ATOM-Feed, Metadata, OpenSearch, GEOportal.NRW

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List of Abbreviations

| | |
|---------|--|
| ASF | ATOM Syndication Format |
| CRS | Coordinate Reference System |
| CSW | Catalogue Service for the Web |
| EU | European Union |
| GDI | Geodateninfrastruktur |
| GUI | Graphical User Interface |
| INSPIRE | Infrastructure for Spatial Information in the European Community |
| ISO | International Organization for Standardization |
| JRC | Joint Research Center |
| LS | Lower Saxony |
| NRW | North Rhine-Westphalia |
| OGC | Open Geospatial Consortium |
| RP | Rhineland-Palatinate |
| SDI | Spatial Data Infrastructure |
| SHP | Shapefile |
| WFS | Web Feature Service |
| WMS | Web Mapping Service |
| XML | Extensible Markup Language |

1 Introduction

1.1 Motivation

With the directive 2007/2/EC of 15th May 2007 the European Parliament did a big step towards a common SDI in the European Community. Right now this directive called INSPIRE (INfrastructure for SPatial InfoRmation in Europe) is in implementation all over Europe and it turned out to be a big challenge for all the members. The implementation of INSPIRE is a very recent topic, because the provision obligation affects every public authority. Some stakeholder already realized the huge potential behind this topic and put a lot of work into it. But there are several problems and difficulties that come along with the implementation rules, which also act as a deterrent to the concerned.

Technically the goal of INSPIRE is an area-wide cross-border use of geodata, which should be reached by standardized web services and prescribed data models. Search, visualization and download are the main use cases within the 'Publish-Find-Bind' paradigm of INSPIRE. That finally leads to Discovery-, View-, and Download Services, whose precondition is the dynamic access to interoperable available geodata. The European Commission provide several official documents in order to promote a consistent implementation in Europe.

This thesis will focus on Download Services in NRW. The recommended way for providing Download Services for INSPIRE are ATOM-Feeds. Up to now the realization of ATOM-Feeds in NRW is still at the beginning – the thesis will investigate possible solutions in order to help developing a methodology for the implementation. On the first glance ATOM-Feeds are an effective solution and easy to implement, but the investigation will show that there are much more aspects to consider in order to integrate them successfully into existent architectures and workflows.

Area under investigation is the GEOportal.NRW, which is central access point for the spatial data infrastructure in NRW and the main component for the INSPIRE implementation. Even if NRW did a good progress in the INSPIRE topic, there are still ambiguities and a clear direction is not always in sight. Especially the smaller members and communes are facing problems due to the lack of know-how and financing difficulties. Therefore the top level authorities try to support the smaller members. They provide guidelines and instructions and arrange information events.

This thesis will take a part in this support by clarifying ambiguities, testing realization alternatives and developing implementation strategies for INSPIRE Download Services in NRW.

1.2 Research Questions and Goal

The thesis adheres closely to following research questions:

- What implementing alternatives for automatic generation of ATOM-Feeds based on ISO metadata exist?
- How do the identified solutions suit in order to fulfil the requirements of NRW?

Main goal is to provide support for the development of a strategy for implementing Download Services with predefined ATOM-Feeds. Simplified this is done here in mainly two steps: First the possible software solutions are identified and tested. Secondly these solutions are reviewed and integrated into the architecture of NRW in order to develop an implementation strategy.

Due to the complexity of INSPIRE and the wide range of possible research topics, a clear classification of the topic is necessary. Otherwise the research topic could easily drift away and let the dimension of the thesis expand massively. Therefore there are a list of topics that this thesis will not cover, even if they are important elements in the implementation of INSPIRE, e.g. View Services, direct-access Download Services, data specifications, transformation, harmonization.

1.3 Methodology

The research done can be divided in three elementary work steps: Basics research, requirement analysis and concept development (see Figure 1). The first step forms the foundation for rest of the work. At this point research about background and required technologies takes place as well as the investigation of the current status in NRW. That was mainly done by web research and interviews with responsible persons. Based on that knowledge in the second step the requirements were identified. On the one hand the technical requirements for ATOM-Feeds and on the other hand the general requirements for the architecture in NRW. Finally the analysis of existing software solutions and the development of an implementation strategy will complete this conceptual thesis.

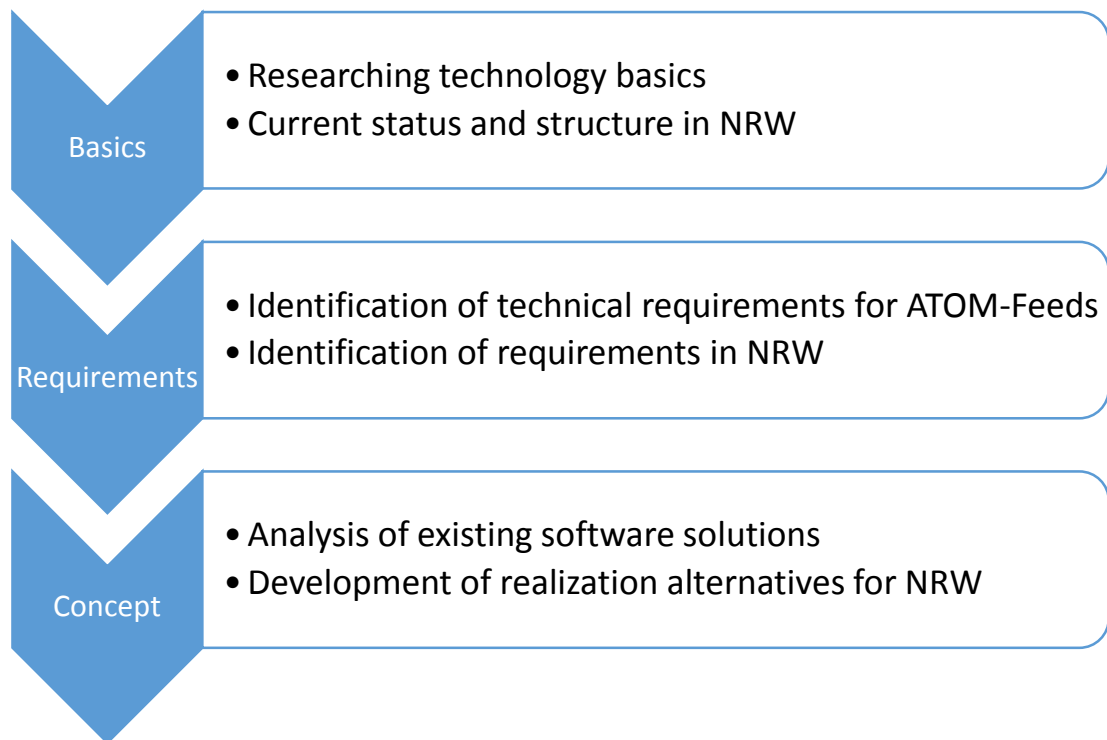


Figure 1: Methodology of the thesis [own diagram]

1.4 Structure

The thesis begins with an introduction with the two aspects ‘What is the topic?’ and ‘How to approach the topic?’ The motivation part and the research questions deal with the what-question. At that point a presentation of the topic takes place as well as a first brief introduction into the problem. After this the methodology and structure chapters describe how to approach the problem. Research methods and the chain of thought are mentioned at this point.

The ‘Basics’ section provides all the information that is required to understand the following chapters. INSPIRE is a wide topic, a closer look at the details is necessary at this point. Important aspects here amongst others are specification documents, web services, time plan and problem. Another basic aspect is the used technology. That means metadata, ATOM-Feeds and OpenSearch will also need a closer consideration. ‘Related work’ covers the aspect of literature research. Selected papers will be examined in this chapter with the main focus on relevance regarding to the research questions.

The deeper research work begins within the requirement analysis. At that point different aspects need to be investigated. On the one hand the technical requirements for providing ATOM-Feeds that are mostly defined in official documents and on the other hand the specific requirements for North Rhein-Westphalia that are derived by the status quo and the architecture of the GEOportal.NRW. Use-case descriptions and definition of criteria are also part of the requirements. That makes this chapter the most detailed of the thesis.

The chapter 'Analysis of Existing Technologies' lists existing software solutions for working with ATOM-Feeds and shows how other institutions use them to already provide INSPIRE Download Services. The interplay of these results and the requirement analysis leads to 'Realization Alternatives. Here the requirements and software solutions are brought together to review the potential for an implementation in NRW. Different workflows and use-cases are presented and compared in order to develop and present a concept. The Discussion evaluates the identified solutions. Finally the conclusion gives an overall summary of the results and findings. See Figure 2 for an overview.

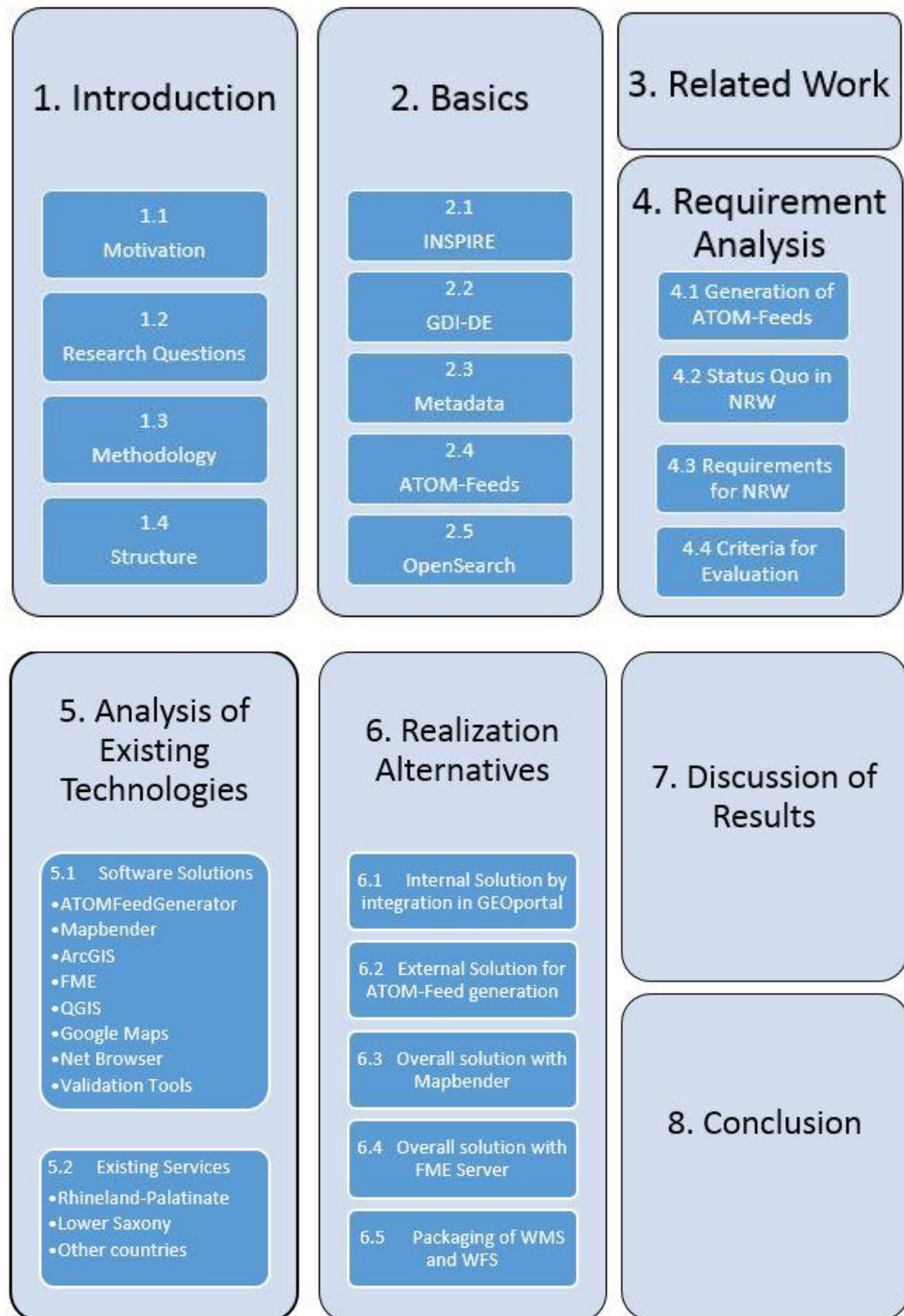


Figure 2: Structure of thesis [own diagram]

2 Basics

The basics chapter provides the background knowledge for the rest of the thesis and gives an overview of important aspects. It begins with a brief introduction to INSPIRE with focus on network services, specification documents and problem. After this view of the whole picture in Europe it is necessary to look at the national level, which is done in the 'GDI-DE' section. A very important part of the thesis is the metadata topic. Therefore it gets an own introduction part with focus on mapping, ISO-schemas, CSW and the 'GEOkatalog.NRW'. Another aspect that needs closer consideration is ATOM. Structure and function will be examined as well as examples and the GeoRSS extension.

2.1 INSPIRE

INSPIRE is an acronym for 'Infrastructure for Spatial Information in Europe', it stands for directive 2007/2/EG [INSPIRE D] of the European Parliament from 15th May 2007. It demands member states to transcribe the directive into national right within two years. In Germany this lead into the 'Geodatenzugangsgesetz' [GeoZG] of 10th February 2009 and the 'Geodatenzugangsgesetz NRW' [GeoZG NRW] of 17th February 2009. Goal is a cross-border usage of geodata in Europe with help of web-based services for search, visualization and download. A common European SDI has big potential, many institutions would take advantage. INSPIRE should especially assist policy-making in relation to activities that may have an impact on the environment. Currently there are problems regarding availability, quality, organization, accessibility and sharing of spatial information across the levels of public authorities (see INSPIRE D, p. 1).

Not every spatial dataset is affected by the INSPIRE directive. The authorities have to review the relevant dataset on their own, based on following list of criteria (see INSPIRE D, p. 5):

The dataset...

- ...relates to an area where the authority has jurisdictional rights.
- ...is in electronic format.
- ...is held by a public authority.
- ...is an original reference version.
- ...relates to one of the Annex Themes I, II or III.

| INSPIRE data themes | | |
|---|--|---|
| Annex I <ol style="list-style-type: none"> 1. Coordinate reference systems 2. Geographical grid systems 3. Geographical names 4. Administrative units 5. Addresses 6. Cadastral parcels 7. Transport networks 8. Hydrography 9. Protected sites | Annex III <ol style="list-style-type: none"> 1. Statistical units 2. Buildings 3. Soil 4. Land use 5. Human health and safety 6. Utility and governmental services 7. Environmental monitoring facilities 8. Production and industrial facilities 9. Agricultural and aquaculture facilities 10. Population distribution – demography | <ol style="list-style-type: none"> 11. Area management/ restriction/regulation zones & reporting units 12. Natural risk zones 13. Atmospheric conditions 14. Meteorological geographical features 15. Oceanographic geographical features 16. Sea regions 17. Bio-geographical regions 18. Habitats and biotopes 19. Species distribution 20. Energy Resources 21. Mineral resources |
| Annex II <ol style="list-style-type: none"> 1. Elevation 2. Land cover 3. Ortho-imagery 4. Geology | | |

Figure 3: INSPIRE data themes [CETL]

The topics of INSPIRE Annex Themes are listed above (see Figure 3). The annex number indicates the time schedule for provision of the INSPIRE services. For example Download Services for Annex I and II Themes must be prepared INSPIRE conformal until 2012, Annex III Themes until 2013. Interoperable Download Services must be available until 2017 (I + II) and 2020 (III). *Interoperable* means that datasets exist in the INSPIRE data model that is defined in the Data Specification of the particular Annex Theme [INSPIRE DS PS]. *Conformal* Services fulfil the requirements of network services [INSPIRE IR NS]. See Figure 4 for the roadplan of INSPIRE.

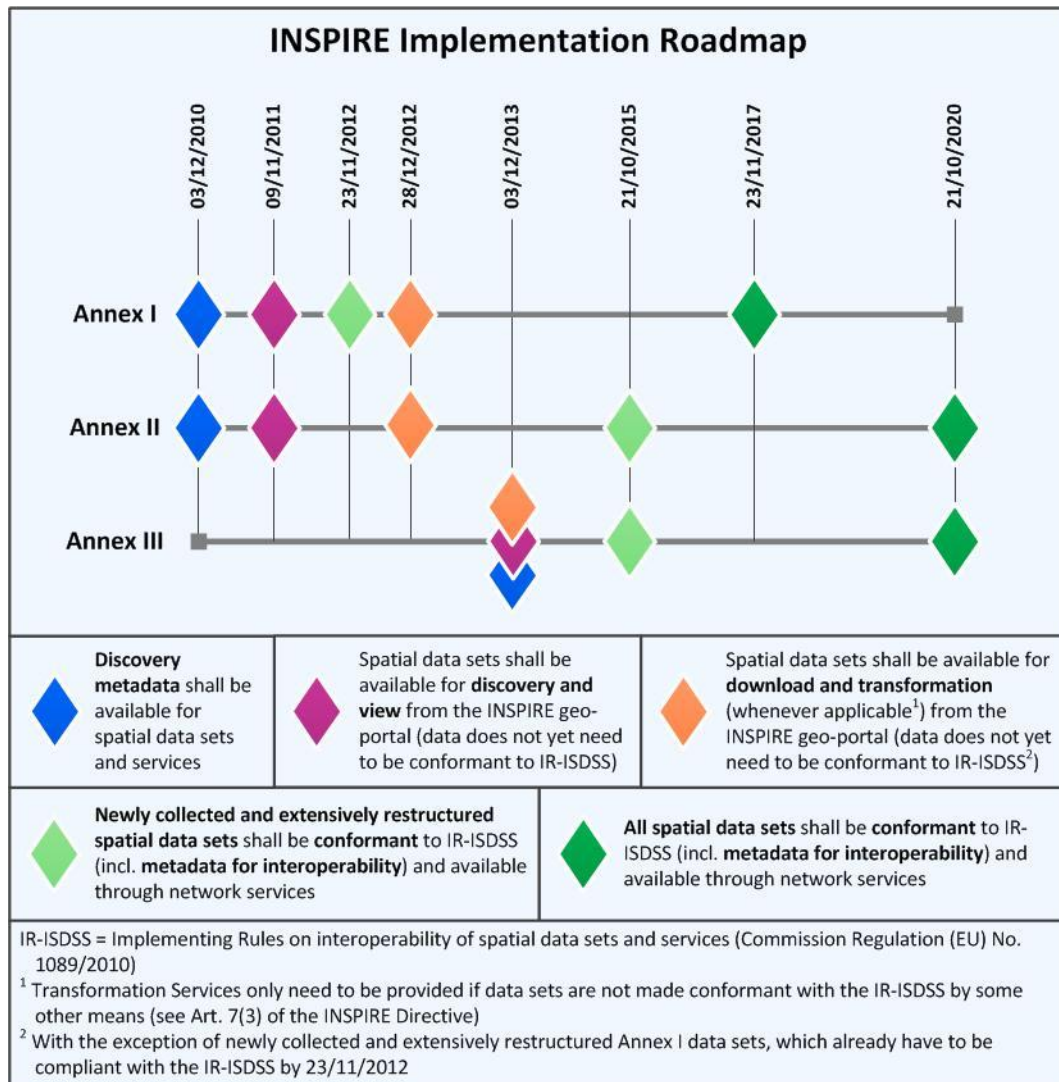


Figure 4: Roadplan for INSPIRE [EC RO]

The INSPIRE directive document differentiate between five main topics [GDI-DE DI]:

- Metadata: defines the description of datasets and services
- Data Specifications: determine data models for the specific Annex Themes
- Network services: requirements about performance of services
- Data sharing: development of licensing and copyrights
- Monitoring/ Reporting: defines indicators for quality management of spatial data and prescribes reporting rules

The European Commission provides implementation support in terms of two documents for each of the topics above: Implementing Rules (IR) and Technical Guidance (TG). While Implementing Rules are obligatory documents, the Technical

Guidances are supporting documents that give suggestions for the implementation. See Table 1 for a comparison of the two type of documents.

Table 1: Differences of Implementing Rules and Technical Guidance

| Implementing Rules | Technical Guidance |
|---|---|
| Mandatory | Optional |
| Requirements for implementation | Suggestions, help for developers |
| e.g. Data Specifications for data models | e.g. usage of ATOM-Feeds |
| Define requirements and specifications, but do not prescribe specific technologies in order to achieve them | Suggested technologies are based on standards (ISO, OGC), extended with INSPIRE specifics |
| Goal: definition of consistent specifications – conformal + interoperable | Goal: Supporting developers with implementation strategies |

Relevant documents for this thesis are:

- Metadata Implementing Rules [INSPIRE IR MD]
- Metadata Implementing Rules: Technical Guidelines [INSPIRE TG MD]
- Technical Guidance for the implementation of INSPIRE Download Services [INSPIRE TG DS]
- Network Services Implementing Rules [INSPIRE IR NS]

Equivalent documents for the implementation on national level are also existent. For Germany GDI-DE and GDI-NW published several best-practice guides called ‘Handlungsempfehlung’ and ‘Leitfaden, see chapter 2.2 for detailed information.

2.1.1 Problem

As already mentioned INSPIRE is a very complex topic with a difficult implementation due to the variety of specifications and requirements. That makes it not easy for the data provider on communal level to provide interoperable INSPIRE Network Services. They don't have the required know-how and manpower for taking all the steps of identification, harmonization and publication. For this reason many stakeholders put INSPIRE back and hope for support from the top level authorities. The federal state authorities provide help in terms of guidance documents and implementing the GEOportal.NRW. Furthermore several local authorities try to initiate spatial data infrastructures within the rural district in order to support the communes and to face the INSPIRE challenge together [GDI-WAF] [ROHRBACH].¹

A method for simplifying INSPIRE is using ATOM-Feeds instead of WFS services for implementing Download Services. This solution is simpler but still very complex because the master plan is missing. There are still a lot of uncertainties and open questions about this topic. Over the course of this thesis it hopefully becomes clear how to approach this problems.

2.1.2 Network Services

The INSPIRE directive postulates four types of network services [GDI-DE WIKI]:

- INSPIRE Discovery Service
- INSPIRE View Service
- INSPIRE Download Service
- INSPIRE Transformation Service

Discovery Services provide search functionality in order to find metadata about spatial data and services. The Service also presents the content of discovered metadata. In Germany the central Discovery Service 'Geodatenkatalog.de' is provided by GDI-DE.

View Services allow users to visualize spatial data with help of Web Map Services. The results of referenced image data can be displayed in different projections and scales or can be integrated into web-based applications in order to visualize maps.

¹ Implementation in Steinfurt: <http://prezi.com/h77gxjewifzs/inspire-umsetzung-kreis-steinfurt/>

With Download Services users can directly access spatial data from the provider. The Technical Guidance for Download Services define three alternatives for the implementation:

- Pre-defined Dataset Download Service based on ATOM
- Pre-defined Dataset Download Service based on WFS
- Direct Access Download Service

Pre-defined ATOM-based Download Services provide Service- and Dataset-Feeds that contain links to the datasets. There are no filter capabilities possible, dataset must be downloaded in full. The same applies to pre-defined Download Services based on WFS. There is just one stored query possible in order to retrieve the full dataset, no filtering is possible. The direct-access Download Service extends the pre-defined version by additional ISO 19143 conformance classes. That enables detailed attributive, spatial and temporal selections. Shortly pre-defined Download Services are the much simpler solution, but the direct access alternative has the benefit of filtering possibilities. That allows the customer to download not only the full dataset, but also a subset.

Transformation Services allow the transformation of spatial datasets. They are only necessary, if the datasets are not directly available in the required format. Therefore, the data providers are only obliged to provide the relevant spatial data sets through view and download services [GDI-DE NS].

Chapter 2.3 takes a detailed look at the topic of metadata and Discovery Services. ATOM-Feeds are introduced in chapter 2.4. The thesis will focus on pre-defined Download Services with ATOM-Feeds, direct access services and WFS are not part of the research.

2.1.3 Publish-Find-Bind

The provision of geodata works on the Publish-Find-Bind principle:

- The provider *publishes* a service in the catalog. Now the service is findable for consumers
- The consumer searches in the catalog and receives a search result (*find*)
- Based on the result the consumer can access the service of the provider (*bind*)

The figure below shows the principle in schematic representation. This architecture is the reason for the need of clear interface definitions and consistent network services. Precondition for an interaction between stakeholders and components as described above is a complex architecture as postulated in the INSPIRE directive.

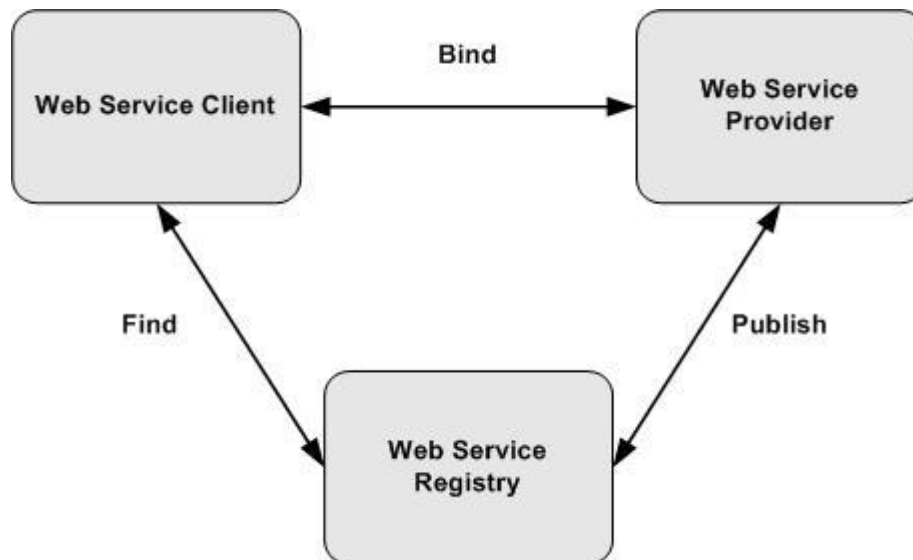


Figure 5: Publish-Find-Bind [WHIPPLE]

2.2 GDI-DE

The GDI-DE is the main coordination central for INSPIRE in Germany. The Steering Committee is the decision-making body for the setup of the Geodata Infrastructure in Germany. Members are representatives of the Federal Government, states and local authorities. The Coordination Office (Kst. GDI-DE) has consulting and communicative functions for implementation of GDI-DE concepts. Tasks of GDI-DE are [GDI-DE T]:

- Development of a common concept by the Federal Government, the Länder (states) and local authorities for the open setup of a GDI in Germany as a component of a European spatial data infrastructure still to be established.
- Guidance and coordination of the relevant measures initiated by the Länder, local authorities and the Federal Government for the development, revision and implementation of norms and standards with European and international Geodata Infrastructures.
- Definition of model projects for the setup of networked geodata portals in Germany according to the principle 'some for all'.

- Taking care of the mandatory provision of the National geodatabase (NGDB) through the public administrations of the Federal Government, the Länder and the local authorities

The GDI-DE comprises four permanent research groups for technical issues that represent an important connection link between administration and industry [GDI-DE RG]:

- Architecture
- Metadata
- Geoservices
- SIG 3D

The working groups publish documents that define specifications and support developers for the implementation of a corporate spatial data infrastructure. Important publications for this thesis are e.g. 'Architektur der Geodateninfrastruktur Deutschland – Konventionen zu Metadaten' and 'Handlungsempfehlungen für die Bereitstellung von INSPIRE konformen Downloaddiensten (INSPIRE Download Services)'. Especially the best-practice guides (Handlungsempfehlung) are useful for developers by providing implementation strategies based on current state of the technology. See Figure 6 for an overview of the document hierarchy.

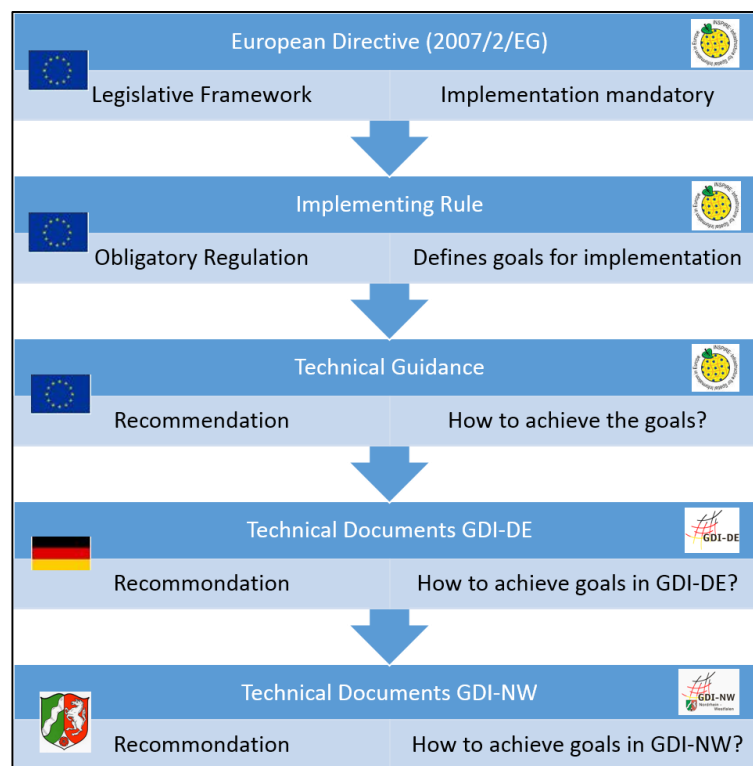


Figure 6: INSPIRE Document Hierarchy, own diagram based on [HOGREBE]

The GDI-DE is also responsible for following central components [GDI-DE C]:

- GDI-DE Testsuite: tool for validation of metadata and network services [see chapter 5.1.8]
- Geodatenkatalog.de: search service for all available geodata and services of GDI-DE
- Geoportal.de: geoportal which offers options to search, link and visualize geodata
- GDI-DE Registry: information system for administration and support of multisectorial components²

Geoportal and Geokatalog are primarily targeted to consumer, Testsuite and Registry are for geodata providers. Many of the components can be found analog in the architecture of GDI-NW, which will be investigated later [see chapter 4.2].

2.3 Metadata

Metadata is 'data about data' that is used in case of big data collections. An example is a library database that provides information about the stored books. Every metadata set stands for a single book with specific properties. These attributes are for example book title, publication year and author - stored in a catalog. The metadata catalog allows to search for specific properties (attributes) in order to find a suitable book. This principle is portable to a catalog that provides metadata about geodata.

The metadata topic is a crucial part not just in this thesis but in the whole context of INSPIRE, because every geodata set and every network service must be described by metadata. This metadata will be used to manage and categorize the data and make it searchable and findable. That is called INSPIRE Discovery Service.

The standard formats for providing metadata for geographic information is defined in ISO 19115 [ISOa] for datasets and ISO [ISOb] 19119 for services. They describe the XML structure and necessary attribute. It is possible to register around 400 attributes for ISO conformal metadata, but INSPIRE requires only following list of attributes (with German description, based on the metadata definition of German catalogs):

² The Registry is in development

Dataset

| INSPIRE | ISO 19115 |
|---|---------------------------|
| Ressourcenbezeichner | Titel |
| Ressourcenüberblick | Kurzbeschreibung |
| Ressourcenart | Hierarchieebene |
| Eindeutiger Ressourcenbezeichner | Identifikator |
| Ressourcensprache | Sprache |
| Themenkategorie | Thematik |
| Schlüsselwort | Schlüsselwort |
| Geografisches Begrenzungsrechteck | W/Ö Länge, S/N Breite |
| Datum | Datum |
| Herkunft | Erläuterung |
| Spezifikation | Spezifikation |
| Grad | Bestanden |
| Bedingungen für Zugang und Nutzung | Anwendungseinschränkungen |
| Beschränkungen des öffentlichen Zugangs | Andere Einschränkungen |
| Zuständige Stelle | Kontakt |
| Funktion der zuständigen Stelle | Funktion |
| Kontakt für die Metadaten | Kontakt |
| Datum der Metadaten | Datum |
| Sprache der Metadaten | Sprache Metadaten |

Service

| INSPIRE | ISO 19115 |
|-----------------------------------|-----------------------|
| Ressourcenbezeichner | Titel |
| Ressourcenüberblick | Kurzbeschreibung |
| Ressourcenart | Hierarchieebene |
| Schlüsselwort | Schlüsselwort |
| Geografisches Begrenzungsrechteck | W/Ö Länge, S/N Breite |
| Datum | Datum |
| Spezifikation | Spezifikation |
| Grad | Bestanden |

| | |
|---|---------------------------|
| Bedingungen für Zugang und Nutzung | Anwendungseinschränkungen |
| Beschränkungen des öffentlichen Zugangs | Andere Einschränkungen |
| Zuständige Stelle | Kontakt |
| Funktion der zuständigen Stelle | Funktion |
| Kontakt für die Metadaten | Kontakt |
| Datum der Metadaten | Datum |
| Sprache der Metadaten | Sprache Metadaten |

Datasets and services that are affected by INSPIRE Annex Themes are indicated with the keyword (Schlüsselwort) 'inspireidentifiziert'. So it is possible to find INSPIRE relevant data within catalogs by simply searching for the keyword.

2.3.1 CSW

The method to access metadata from a catalog is defined through a CSW interface. CSW stands for the OGC standard 'Catalog Service for the Web'. The service does not provide spatial data, it offers an access to descriptive metadata. The recent version 2.0.2 is the basis of INSPIRE catalog services [WEICHAND CSW]. Three types of requests are possible:

Selection – information for customers about spatial data and services

- GetCapabilities - returns the properties of requests that are accepted by the server
- DescribeRecord - returns information about the model of records
- GetRecords - search for records, returning record IDs
- GetRecordsById - returns records, specified by their ID

Transaction – edit, update and delete metadata

- Transaction - create/edit metadata by pushing the metadata to the server

Harvest – transfer a metadata between catalog services

- Harvest - create/update metadata by asking the server to pull metadata

The harvest functionality allows to transfer the metadata from an external catalog into the own catalog. This applies in spatial data infrastructures in order to provide a central search functionality. In Germany the catalogs of the states (Bundesländer) harvest the metadata of local catalogs and provide a search functionality that include all the collected data. The central catalog of NRW is the GEOkatalog.NRW. The principle of harvesting is element of the INSPIRE architecture. When finalized, the top-level geoportal of the EU will include all the metadata information of the local catalogs in Europe (see Figure 7).

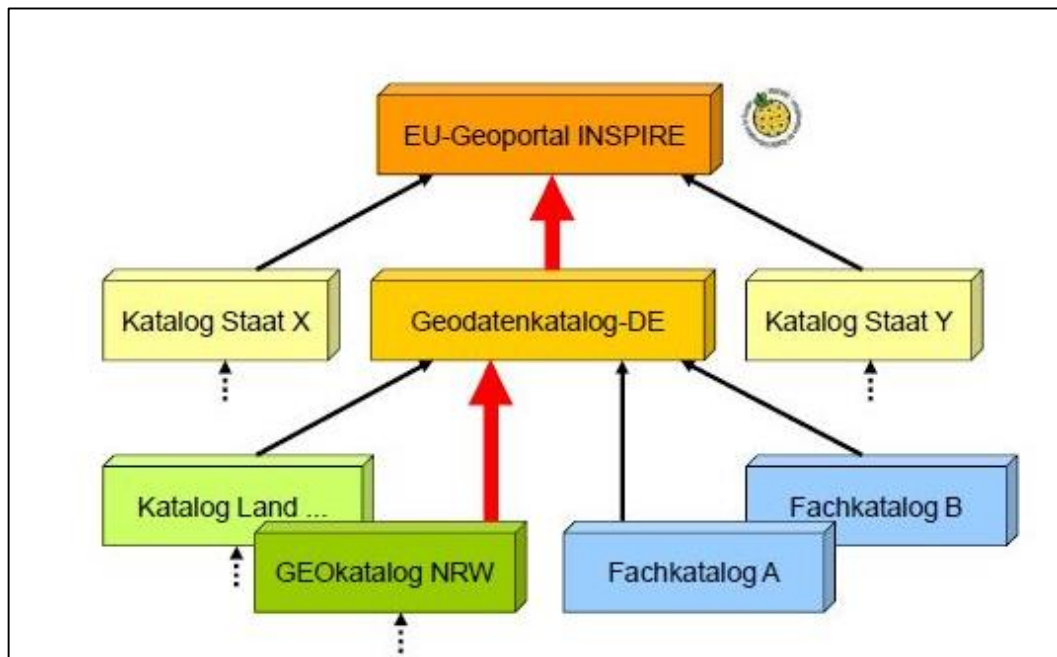


Figure 7: Architecture of metadata catalogs [KOCHMANN]

The response of a CSW-Request is always a XML document. Widely spread software tools for implementation of CSW conform metadata catalogs are GeoNetwork open source³ and smart.finder SDI (terra.catalog)⁴.

Example for a getRecordById-Request on the GEOkatalog.NRW:

<http://www.geoportal1.nrw.de/soapServices/CSWStartup?Service=CSW&Version=2.0.2&ElementSetName=full&outputSchema=http://www.isotc211.org/2005/gmd&Request=GetRecordById&Id=c8550294-4516-4dd9-9fb0-8d8531eb703b>

³ <http://geonetwork-opensource.org/>

⁴ <http://conterra.de/de/software/sdi/index.shtm>

2.3.2 GEOkatalog.NRW

The GEOkatalog.NRW as part of the GEOportal.NRW is the central point for metadata registration and provision in NRW. The catalog is characterized by an easy to use search engine and the intuitively usable user interface. Technically it is based on the software terra.catalog, supporting all required CSW requests. Important aspect at this point is the harvesting functionality that allows the integration of other metadata catalogs. Currently following 12 catalogs are harvested: GDI Südwestfalen, Kreis Gütersloh, Kreis Lippe, Kreis Mettmann, Kreis Warendorf, Stadt Bielefeld, Stadt Bochum, Stadt Bottrop, Stadt Dortmund, Stadt Hamm, Umweltportal Deutschland, Wasser- und Schifffahrtsverwaltung des Bundes.

The catalog complies with all requirements for INSPIRE Discovery Service. Besides the OGC CSW 2.0.2 interface it provides functionality for registration, validation, visualization and searching of metadata. Summarized the performance features are [IMA GDI-NW]:

- Web-based registration, validation und publication of metadata
- ISO (19115/19119/19139) and INSPIRE conformal
- CSW 2.0.2 interface⁵
- Search for thematic, spatial and temporal criteria
- OpenSearch functionality for search with browser

Main element is the smart.editor, which provides a user interface for the maintenance of metadata. At this point data providers can register datasets or services by simply filling in forms or using several templates. The metadata profile used is based on the INSPIRE specification, but is extended by additional attributes from the ISO profile. That means the metadata has NRW specific characteristics.

⁵ <http://www.geoportal1.nrw.de/soapServices/CSWStartup?>

The screenshot shows the GEOportal.NRW interface. The top navigation bar includes links for Startseite, Sitemap, Nutzungsbedingungen, Kontakt, and Impressum. The main menu on the left lists various search and publication options. The central area displays the 'Detailsansicht' for the 'INSPIRE Download Service Adressen NRW' dataset. The metadata is organized into tabs: Beschreibung, Kategorisierung, Zugriff, Vertrieb, Qualität, and Metadaten. The 'Beschreibung' tab is active, showing the following information:

- Dienst Status:** Freigegeben
- INSPIRE Download Service Adressen NRW**
- Kurzbeschreibung:** Dieser Dienst stellt die für das INSPIRE-Annex-Thema Adressen aus den Hauskoordinaten umgesetzten Daten zu den Adressen NRW als WFS bereit. Bitte beachten: Dieser Dienst befindet sich zur Zeit noch im Aufbau und kann daher u.U. bezüglich der ... download (OGC-WFS 2.0.0)
- Erzeugung:** 2013-07-15
- Publikation:** -
- Revision:** -
- Rolle:** Ansprechpartner
- Name:** Peter Kochmann
- Organisation:** Bezirksregierung Köln, Geobasis NRW
- Position:** Gst. IMA GDI.NRW

On the right side, there is a map of North Rhine-Westphalia showing the distribution of the data.

Figure 8: Metadata of a Download Service in the GEOkatalog.NRW [Screenshot]

The screenshot shows the 'Smart.Editor' interface for registering metadata. The top navigation bar is the same as in Figure 8. The main menu on the left is also the same. The central area displays the 'Beschreibung' tab for a new dataset. The form includes the following fields:

- Titel:** A text input field.
- Alternativtitel:** A text input field with a red minus icon.
- Zusammenfassung:** A large text area for a summary.
- Vorschaugrafik:** A text input field with a red minus icon.
- Referenzdatum:** A dropdown menu showing '1'.
- Referenzdatum:** A text input field with the value '2010-01-01'.
- Datumstyp:** A dropdown menu with the value 'Erzeugung'.

At the bottom left, the URL 'https://www.geoportal.nrw.de/index.php' is visible.

Figure 9: Smart.Editor - interface for the registration of metadata [Screenshot]

2.4 ATOM-Feeds

This chapter describes in general the ATOM syndication format. For predefined INSPIRE ATOM-Feeds see chapter 4.1.1.

“Atom is the name of an XML-based Web content and metadata syndication format, and an application-level protocol for publishing and editing Web resources belonging to periodically updated websites.” [ATOM]

ATOM stands for the ATOM Syndication Format (ASF), a XML language used for web feeds. It is used to publish news on websites by providing feeds that can be updated and displayed dynamically. It is a simple, cheap alternative for providing recent information. By subscribing to a feed the customer will get constantly the latest information and news in chronological order. The format was developed 2003 by amazon as a replacement of RSS, which had limitations and flaws [TROTT]. The benefit of ATOM compared to RSS is the possible identification of differences of plain text and HTML. RSS is only able to read normal text in the entries, but ATOM also recognizes HTML expressions. That means formatting of the entries and embedding of media file is possible, which can be used to improve the appearance of feeds. Another difference to RSS is the mandatory integration of a date. Because of these reasons ATOM-Feeds got more and more popular in recent years and now they even got part of INSIPRE as a core feature for predefined Download Services.

2.4.1 Structure

ATOM-Feeds are well-formed XML documents, composed by a container and any number of entry elements. In addition to the mandatory attributes ID, title and updated there are several further recommended and optional attributes [IETF]. They can be extended without limitation, this is done in case of INSPIRE.

Attributes:

Table 2: ATOM-Feed attributes

| Attribute | required | recommended | optional |
|------------------|-----------------|--------------------|-----------------|
| ID | X | | |
| Title | X | | |
| Updated | X | | |
| Author | | X | |
| Link | | X | |
| Category | | | X |
| Contributor | | | X |
| Generator | | | X |
| Icon | | | X |
| Logo | | | X |
| Rights | | | X |
| Subtitle | | | X |

Entries:

| Attribute | required | recommended | optional |
|------------------|-----------------|--------------------|-----------------|
| ID | X | | |
| Title | X | | |
| Updated | X | | |
| Author | | X | |
| Content | | X | |
| Link | | X | |
| Summary | | X | |
| Category | | | X |
| Contributor | | | X |
| Publisher | | | X |
| Source | | | X |
| Rights | | | X |

Example of a simple ATOM-Feed is the News-Feed of golem.de:

<http://rss.golem.de/rss.php?feed=ATOM1.0>

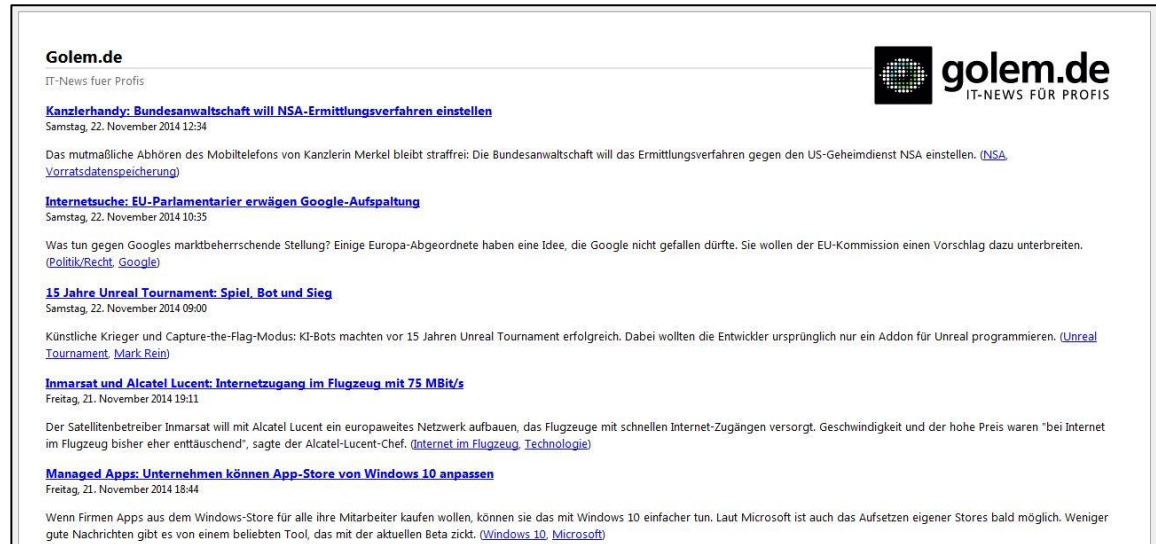


Figure 10: News-Feed based on ATOM in Firefox [Screenshot]

2.4.2 GeoRSS

The extension GeoRSS is available for adding functionality of geographic features to ATOM-Feeds. In INSPIRE context GeoRSS-Simple is used in order to include Point, Line, Bounding Box and Polygon information [GeoRSS]. This is an effective way to enrich feeds with geographic information. An example of this integration is illustrated in Figure 11. It shows the latest earthquakes in USA, every feed-entry stands for one earthquake.⁶ The feeds are referenced with links ('href=...'), that means a click on a feed-entry will lead you to a webpage showing details about the selected earthquake.⁷ The service is visualized in Google Maps in order to demonstrate the geographic features.

⁶ http://earthquake.usgs.gov/earthquakes/feed/v1.0/summary/all_hour.atom

⁷ <http://earthquake.usgs.gov/earthquakes/eventpage/nc72336170>

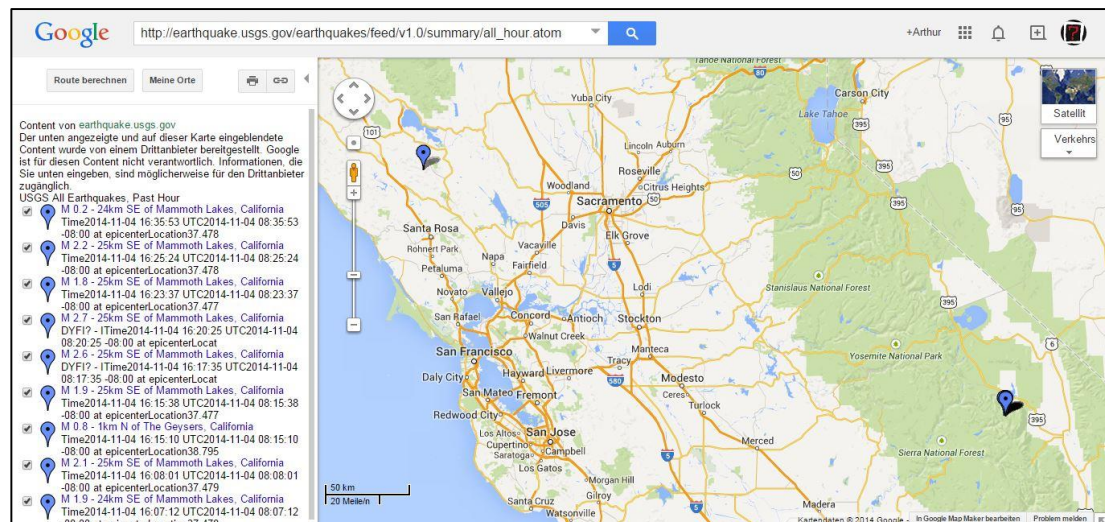


Figure 11: Visualization of a GeoRSS-Feed with Google Maps [Screenshot]

2.5 OpenSearch

OpenSearch was developed by Amazon and published in March 2005 as an open search-engine under the Creative Commons license. It provides several technologies for publishing search results in a standardized format [OpenSearch]. Possible applications of OpenSearch are 'Auto-Discovery' and 'Suggesting Search'. Auto-Discovery is a function of Mozilla Firefox that allows users to integrate search engines of websites into the browser. Firefox detects the custom search protocol and enables users to easily add it to their collection of search options (see Figure 12). Suggesting-Search provides the user with suggested search terms during the entry, this is similar to an auto-complete function. Figure 13 shows an example of Wikipedia search with Firefox.

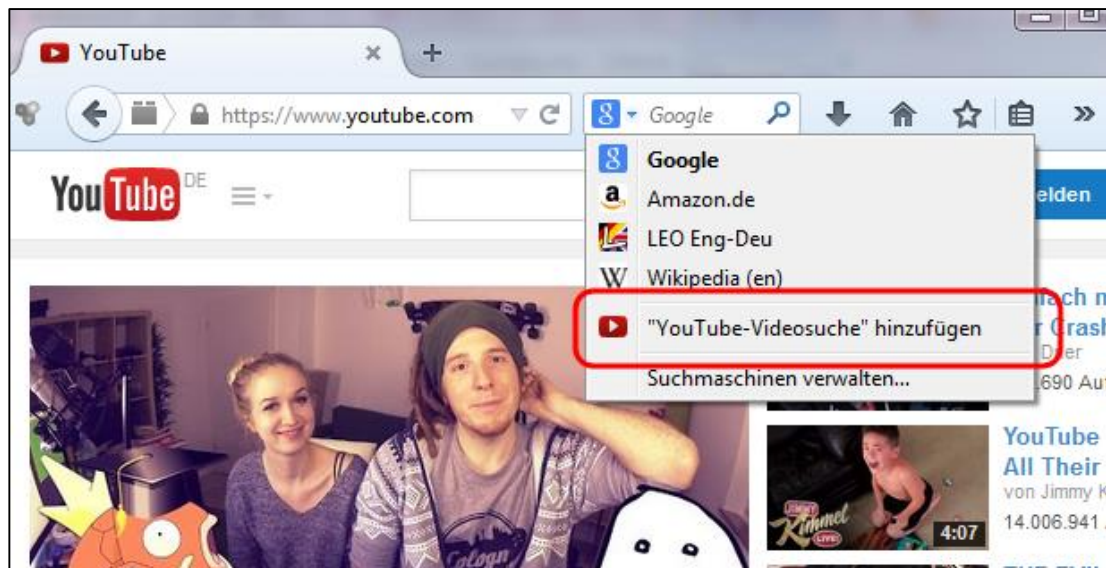


Figure 12: OpenSearch Auto-Discovery in Firefox [Screenshot]

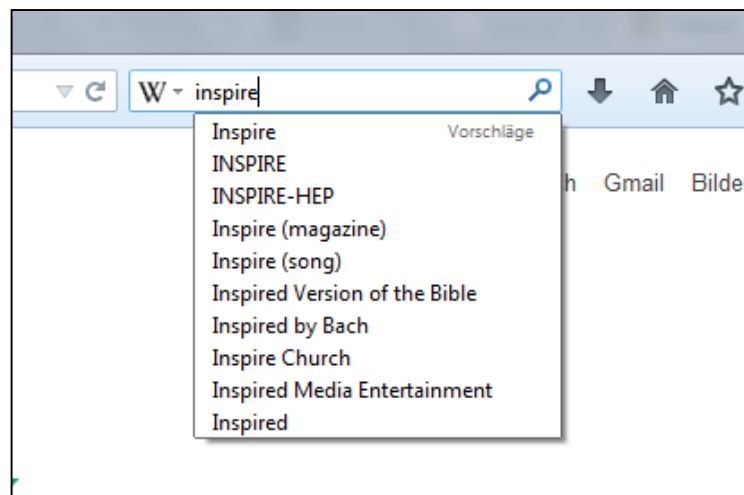


Figure 13: OpenSearch Suggesting-Search [Screenshot]

These applications are only two of many imaginable use-cases. OpenSearch provides much more possibilities. In the context of INSPIRE it will be used to implement specific operations (see chapter 4.1.1.3). OpenSearch is free and simple, therefore the most sources recommend OpenSearch in combination with ATOM-Feeds as the best-practice solution for providing pre-defined Download Services. Main element is the OpenSearch Description Document, which is a simple XML file that describes the access to a search engine. It contains detailed information about the search engine, the content and attributes of the search.

3 Related Work

INSPIRE comprises a broad range of topics and affects many fields of work. Therefore it becomes clear that there are many publications concerning INSPIRE, but most of them are not relevant for this thesis. Even if there is a need for conceptual work in the topic of pre-defined INSPIRE ATOM-Feeds, only a few reproducible activities are detectable. However especially one paper must be mentioned, the master thesis of Jürgen Weichand [WEICHAND]. In his paper he deals with the topic INSPIRE Download Services. The thesis investigated the whole topic by providing an overall view. The inspection is in general, not for a specific public authority. Direct access services are examined as well as pre-defined services. Even if the focus lies on direct access WFS services, still a big part of the thesis is covered by pre-defined ATOM-Feeds. Similar to this thesis the author looks at possible software solutions explains technologies like OpenSearch. In the context of the paper an ATOM-Feed-Client for QGIS was developed, which will be introduced in chapter 5.1.5. Results of the thesis, besides the QGIS extension, is the insight that an implementation of ATOM-Feeds for INSPIRE is realizable. But there are no concrete software solutions available to automate the generation. The thesis at hand will investigate, whether the situation changed since 2012.

Poth [POTH] investigates standards for Metadata and catalog service. He compares the ISO standards (19115, 19119 and 19139) and the OGC CSW definition to other solutions. The author identifies interoperability problems and reveals weaknesses in the INSPIRE time plan. What make this paper relevant for this thesis is proving the importance of metadata. Before INSPIRE came up metadata played not a big role in spatial data infrastructures. Reasons were the complexity of the specifications and missing software solutions. However INSPIRE gave the impetus for the further development of metadata. Nowadays metadata and catalogs are inevitable, because they are the foundation of INSPIRE, everything is build up on the Discovery Services. So to say due to the emerging importance of metadata for INSPIRE and spatial data infrastructures the relevance grew significantly in the recent years.

Fünfer et al. [FÜNFER] introduce the project 'INSPIRE Geodatenpool Bodensee' that shows the relevance of INSPIRE Download Services. The project is a cooperation of four different countries: Bayern, Baden-Wuerttemberg, Austria and Switzerland. They bundled their competencies in order to cope the challenge of INSPIRE. With this joint research project they aimed a concrete implementation and provision of INSPIRE Download Services. In cooperation with AED-SICAD the software solutions ArcGIS

for INSIPRE and FUSION Data Service were used for the implementation. The result is that both data provider and customer can benefit from a standardized cross-border provision of geodata. And that was enabled by INSPIRE Download Services. This paper shows on the one hand the importance and relevance of interoperable Download Services and on the other hand the great potential of corporations for the INSPIRE implementation.

4 Requirement Analysis

For this conceptual thesis a detailed investigation of the requirements is crucial in order to develop and provide solutions in the next step. The chapter at hand will first analyze the general technical requirements for the generation of pre-defined INSPIRE ATOM-Feeds. It explains terms like Service-Metadata or Data-Service-Coupling and looks at needed operations and the role of OpenSearch. Then the status quo will be inspected, including architecture, stakeholders and used technology. Based on the technical requirements and the current system of NRW the specific requirements for NRW will be figured out. Concluding that is followed by criteria for the final software evaluation. In total this chapter is a structured analytic summary of the current status and requirements for NRW.

4.1 Generation of pre-defined ATOM-Feeds Download Services

Before looking at software solutions it is necessary to inspect requirements for generating pre-defined ATOM-Feeds. On the one hand there are the technical requirements like structure, attributes, operations and OpenSearch. On the other hand there are additional underlying conditions like the existence of Service-Metadata and present Data-Service-Coupling. As already mentioned in chapter 2.1.2 two different approaches are defined for INSPIRE Download Services: direct-access or pre-defined. This thesis deals only with ATOM-Feeds, which is based on the approach of pre-defined datasets. This is simpler to providing direct-access WFS, but still very complex due to the proposed structure. This structure is INSIPRE specific, it is not an OSC standard. Therefore the requirements for generation these ATOM-Feeds are very special.

4.1.1 Technical Requirements

4.1.1.1 *Structure*

The ATOM standard is described in chapter 2.4. However ATOM-Feed for INSPIRE are much more complex. In order to be able to cope with the characteristics of a legal prescribed Download Service a facade of ATOM-Feeds was intended. That is defined by a two-level hierarchy. The top-level feed (Service-Feed) in combination with OpenSearch represents the Download Service. It is the equivalent of an OGC

Capabilities Document for WMS or WFS services. This feed contains entries that link to sub-feeds (Dataset-Feed), which represent the datasets. The Dataset-Feeds can hold different representations of the dataset, for example other formats or coordinate reference systems. Service-Metadata describes the Service and every Dataset-Feed is described by metadata as well. See Figure 14 for the structure of an exemplary INSPIRE ATOM-Feed, including Service-Feed, OpenSearch Description, 2 Dataset-Feeds, 5 datasets and 3 metadata documents (1x Service-Metadata + 2x dataset metadata).

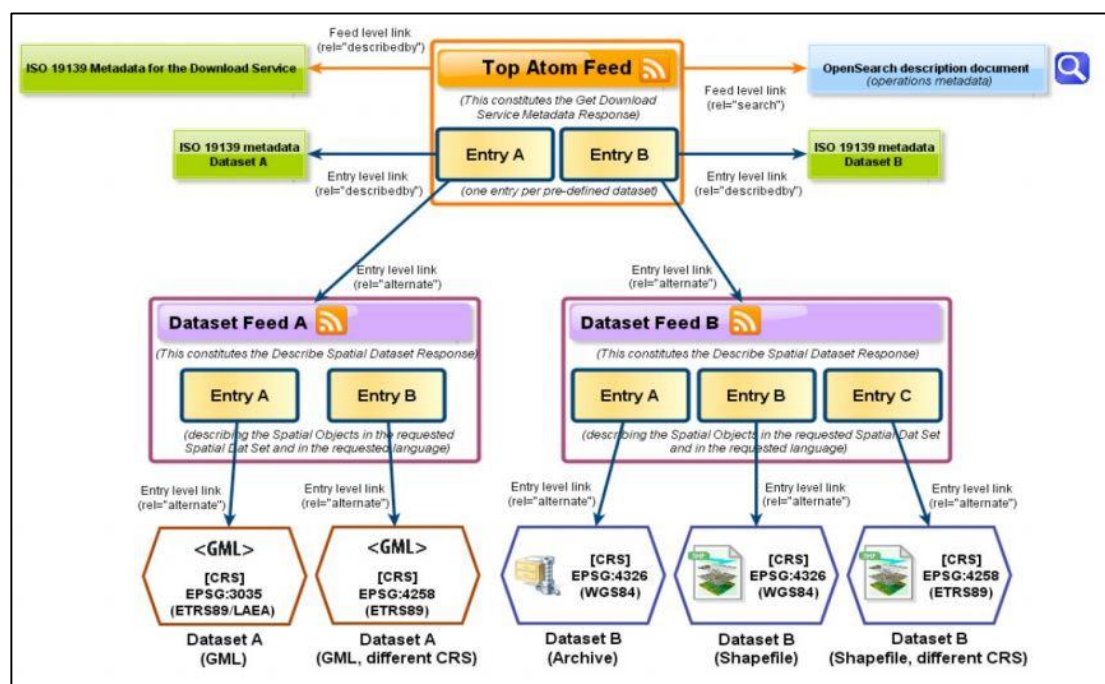


Figure 14: Architecture of INSPIRE ATOM-Feeds [INSPIRE TG-DS]

The characteristic elements of that structure are the links among each other. Feeds, datasets, metadata and OpenSearch must be connected in order to provide the functionalities and operations of a Download Service (see chapter 4.1.1.2). This is done by 'href' link element, which can be distinguished by the 'rel' attribute. Basically all elements of an ATOM-Feed are simple XML documents.

In general a Service-Feed contains following elements:

- Basic information about the Download Service, i.e. title and owner
- Link to the Service-Metadata
- Link to OpenSearch description
- Links to Dataset-Feed(s)

- Basic geographic information about the data, i.e. extent Bounding Box

Corresponding Dataset-Feeds need following elements:

- Dataset metadata
- Link to dataset metadata
- Download links to the datasets

ATOM-Feeds can be generated from ISO Service-Metadatas. Following list shows the required attributes. Detailed mapping tables were already published by MDI-DE [AFG] and GDI-NRW [GDI-NW LF MD]. For more information about Service-Metadatas and possible use cases see chapter 4.1.2 and 4.1.3. Software solutions for the generation based on metadata are introduced in chapter 5.1.

- Title, Sub-Title, Description
- ID
- Date
- Rights
- Contact
- Link to dataset metadata
- Download link of dataset
- Geographic extent

Exemplary INSPIRE ATOM-Feed of JRC:

<http://inspire-geoportal.ec.europa.eu/demos/ccm/democcmdownloadservice.atom.en.xml>

4.1.1.2 Operations

The implementing rules [INSPIRE IR DS] postulate a series of required operations for the implementation of pre-defined ATOM-Feed Download Services. These operations are necessary in order to offer the functional characteristics of a legal Download Service.

Get Download Service Metadata refers to the Service-Feed, which plays the same role as a capabilities document in OGC WFS and WMS. The Service-Feed includes a link to the OpenSearch description document, which enables *Get Spatial Data Set*

and *Describe Spatial Data Set*. The response of Get Spatial Data Set is the pre-defined dataset itself. The response of Describe Spatial Data Set is the Dataset-Feed containing information about the pre-defined dataset. These functions are realized by an OpenSearch interface. The operation *Link Download Service* is provided by a CSW request that directly refers to Service-Metadatas. The purpose of these operations is providing a service-like query interface on top of the static ATOM-Feeds [UK].

Table 3: Download Services operations and results

| Operation | Result | Access |
|-------------------------------|-------------------|--------------------------|
| Get Download Service Metadata | Service-Feed | Link to Download Service |
| Get Spatial Data Set | Dataset-Feed | OpenSearch-Request |
| Describe Spatial Data Set | Dataset | OpenSearch-Request |
| Link Download Service | Service-Metadatas | CSW-Request |

The functionality is demonstrated in following example from MDI-DE [AFG] (Erfassung des Schweinswalbestandes im niedersächsischen Küstenmeer).

Get Download Service Metadata

[http://mdi.niedersachsen.de/atomFeed/getFeedDoc?type=Service
&uuid=61817c1c-43bb-4434-8595-da6873dbfac0](http://mdi.niedersachsen.de/atomFeed/getFeedDoc?type=Service&uuid=61817c1c-43bb-4434-8595-da6873dbfac0)

Get Spatial Data Set

http://mdi.niedersachsen.de/atomFeed/OpenSearchService?request=getDataSet&spatial_dataset_identifier_code=4028478a1d04a5d2011d0a6b372f000f&spatial_dataset_identifier_namespace=http://mdi.niedersachsen.de&crs=http://www.opengis.net/def/crs/EPSG/0/31467&language=de&type=application/x-shapefile

Describe Spatial Data Set

http://mdi.niedersachsen.de/atomFeed/OpenSearchService?request=getDatasetFeed&spatial_dataset_identifier_code=4028478a1d04a5d2011d0a6b372f000f&spatial_dataset_identifier_namespace=http://mdi.niedersachsen.de&crs=http://www.openqgis.net/def/crs/EPSG/0/31467&language=de&type=application/x-shapefile

Link Download Service

[http://nokis.niedersachsen.de/NOKIS/servants/de/disy/preludio2/service/cat/csw/v_2_0_2/GetRecordByIdServant\\$Get?Service=CSW&Version=2.0.2&ElementSetName=full&outputSchema=http://www.isotc211.org/2005/qmd&Id=61817c1c-43bb-4434-8595-da6873dbfac0&Request=GetRecordById](http://nokis.niedersachsen.de/NOKIS/servants/de/disy/preludio2/service/cat/csw/v_2_0_2/GetRecordByIdServant$Get?Service=CSW&Version=2.0.2&ElementSetName=full&outputSchema=http://www.isotc211.org/2005/qmd&Id=61817c1c-43bb-4434-8595-da6873dbfac0&Request=GetRecordById)

Direct Access Download Services require additional operations/functionality: Get Spatial Object and Describe Spatial Object. The implementation for ATOM-Feeds is optional and usually not realized [WILSON].

4.1.1.3 OpenSearch

The OpenSearch technology with its wide range of possible applications was already introduced in chapter 2.5. But it is important to note that the INSPIRE implementation of OpenSearch does not provide full search capabilities. The framework is only used for defining and fulfilling the required operations (see chapter 4.1.1.2).

In order to provide the OpenSearch functionality, two things are needed:

1. OpenSearch Description Document
2. OpenSearch Engine

The description document is a static document describing the type of queries that can be made. Additionally an engine on server side is necessary for providing the

functionality. This web-based service responds to query requests that are defined in the OpenSearch Description Document. These two components are used to provide two operations for INSPIRE Download Services: *Describe Spatial Data Set* and *Get Spatial Data Set*.

The OpenSearch Description Document contains a set of URL templates defining the possible query requests. In case of usual websites this could be a free text search. However for INSPIRE it is used to define some very specific queries in order to implement the relevant operations. A link to the description document is integrated in the Service-Feed, which finally enables the query possibility.

See chapter 4.1.1.2 for examples of possible requests. Software solutions that use this technology are introduced in chapter 5.1.1 (ATOMFeedGenerator) and 5.1.3 (ArcGIS).

4.1.2 Service-Metadata and Data-Service-Coupling

In order to create a cross-border exchange of geodata, how INSPIRE postulates, a well-defined and structured SDI is necessary. This applies particularly, if the project extends over (almost) the whole territory of Europe. Two main aspects for implementing INSPIRE are Service-Metadata and Data-Service-Coupling. Both also play an important role in generating ATOM-Feeds. Service-Metadata, as the name implies, is metadata about a particular Download- or View-Service. Required components for WMS and WFS services within the INSPIRE infrastructure are as follows:

- WMS/WFS Service
- Capabilities Document
- Service-Metadata
- Underlying Dataset
- Dataset Metadata

These elements are linked with each other as demonstrated in Figure 15, this is called Data-Service-Coupling. Coupling is required in order to represent technical related datasets coherently. This makes the interpretation of the data easier [MDI-DE].

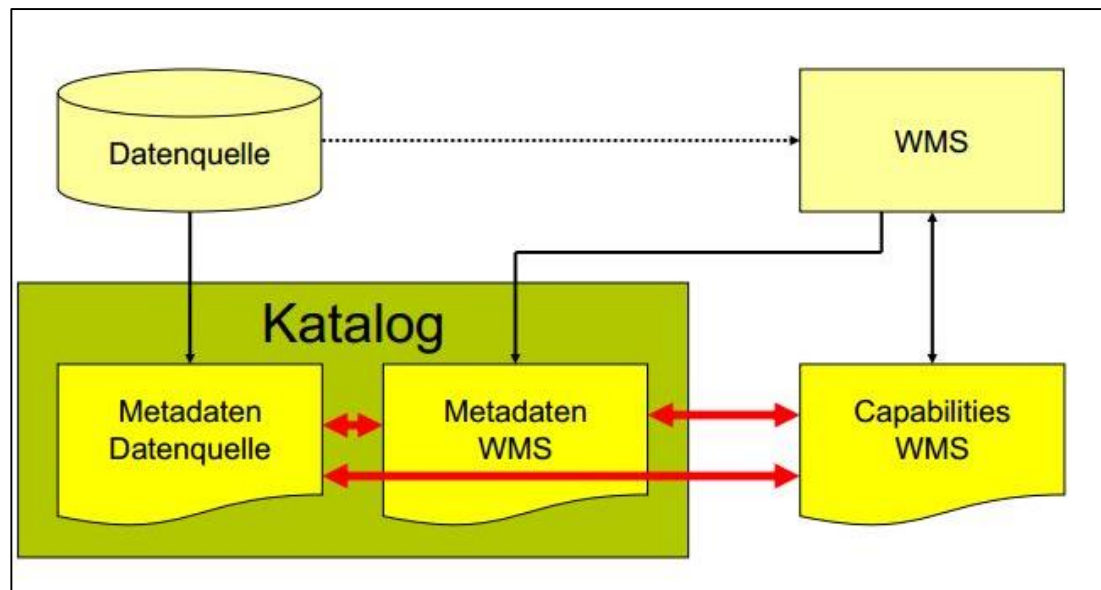


Figure 15: Data-Service-Coupling [KOCHMANN 2013]

The structure for Download Services with ATOM-Feeds is similar:

- Service-Feed
- Service-Metadatas
- Dataset-Feed
- Dataset
- Dataset Metadata
- OpenSearch Description

At this point there is no coupling necessary because the resources are already 'coupled' due to the link-elements within the documents (see diagram ... of chapter 4.1.1.1). Main goal is implementation of the Publish-Find-Bind principle [WAETKE]. In the context of ATOM-Feed generation Data-Service-Coupling is necessary for a specific use case: packaging of datasets based on WFS/WMS (see chapter 4.1.3).

It is important to note that the Service-Feed in the ATOM structure does not replace the Service-Metadatas. That means for an INSPIRE Download Service you will always need both Service-Feed and Service-Metadatas. The Service-Feed corresponds to the OGC Capabilities Document. A conformal INSPIRE Download Service is constructed by the combination of Service-Feeds, Dataset-Feed and Service-Metadatas. Service-Metadatas is precondition for the generation of ATOM-Feeds. See the next chapter for possible use cases.

4.1.3 Generation Methods

Various approaches are imaginable for the generation of pre-defined INSPIRE ATOM-Feeds. First of all following questions must be considered for the choice of a generation method:

- Providing static or dynamic ATOM-Feeds?
- What underlying information is used to generate the ATOM-Feeds?

For the implementation of INSPIRE it is possible to use dynamic ATOM-Feeds that are generated 'on-the-fly'. This is expressly desired and defined in the official documents [GDI-DE HE DD]. Precondition is the availability and accessibility via URL and requests. This method requires an existing consistent infrastructure with clear data structure and conformal metadata. Also server-side scripts are necessary in order to execute the dynamic generation. In Rhineland-Palatinate this is solved with an INSPIRE-Proxy and the software solution Mapbender (see chapter 5.2.1).

When choosing the static method there are a lot of implementation possibilities, too. First the provider has to decide on what the generation should base. In most cases ATOM-Feeds are generated from existing Service-Metadata. But the reverse method is also imaginable, that means creating the feeds at first and then the appropriate Service-Metadata. However the reverse approach is not really practicable and therefore not yet implemented. As already mentioned for the generation of INSPIRE ATOM-Feeds it is necessary to have the Service-Metadata, which contains documental information (Title, Contact ...) as well as links to the dataset metadata. The method based on Service-Metadata is for example used by the ATOMFeedGenerator (see chapter 5.1.1).

Furthermore there is the possibility to use existing WMS and WFS services behind a façade of ATOM-Feeds in order to provide INSPIRE conformant Download Services. These WFS and WMS may be older versions (e.g. WMS 1.1.0), which are not convenient for INSPIRE because of the missing support of stored queries. However with help of ATOM-Feed they can be published as interoperable INSPIRE Download Services. This is done by using pre-defined WFS or WMS requests instead of links to datasets. For the user it is not relevant if he gets the data over a pre-defined query or over a direct link to the dataset [GDI-DE HE DD]. Advantage of this method is that data providers don't have to convert their services into the latest WFS and WMS version for INSPIRE, but can use the existing services with an ATOM façade, which is usually easier to implement. In case of too big datasets, which is a realistic scenario

with WMS and WFS, they can be split into smaller packages. Here every partition will need an own Dataset-Feed representing the link to the WMS/WFS request. The size of the packages must be determined by hand or automatically. In the example below (from Rhineland-Palatinate) the output size for a getMap request was by default automatically set to 1000 x 1000 pixels. The size of WFS request is calculated automatically based on the number of objects.

Example

http://www.geoportal.rlp.de/mapbender/plugins/mb_downloadFeedClient.php?url=http%3A%2F%2Fwww.geoportal.rlp.de%2Fmapbender%2Fphp%2Fmod_inspireDownloadFeed.php%3Fid%3Db23f36c0-8992-f7e1-03a1-461cdf682d9f%26type%3DSERVICE%26generateFrom%3Dall

Chapter 5 will describe possible software solutions for the use cases mentioned. Chapter 6 will analyze realization alternatives by combining the results of 'Generation Methods (4.1.3)', 'Requirements for NRW (4.3)' and 'Existing Technologies (5)'.

4.2 Status Quo in NRW

For reviewing the state of play of the INSPIRE implementation in NRW it is necessary to look at this topic from various perspectives. On the one hand there are the top-level regional authorities like IT.NRW, Geobasis NRW and GDI-NW. On the other hand there are the lower-level parties like communes and cities. The top-level authorities usually have very good possibilities to implement required specifications like INSPIRE. They have personal, software and know-how available in order to fulfill the requirements. By contrast the parties on the lower level of hierarchy have other pre-conditions. In most cases there is neither personal and know-how nor technology available in order to satisfy the complex demands of INSPIRE. Even if they are concerned by just a few Annex-Themes (see chapter 2.1), the implementation is still difficult [DÜRENb]. Therefore they either need help from the top-level or reach an upper-level on their own by incorporating with other cities or districts as already mentioned above (chapter 2.1.1).

An overall central solution for NRW, following the example of Rhineland-Palatinate (see chapter 5.2.1), is not realizable. However the top-level authorities provide different types of support. There are several supportive documents published: e.g. a

guideline for registration of metadata [GDI-NW LF MD] and a master plan [GDI-NW GK]. Furthermore twice a year a conference take place in Düsseldorf in order to inform all responsible persons in NRW about the latest developments and solutions for INSPIRE [GDI-FORUM]. The GDI-NW plays an important role in the overall structure. This initiative was realized by federal state NRW, communes, IT-companies, research centers and users of geographic information. All these members were involved in mobilizing a spatial data infrastructure in NRW in order to improve availability and interoperability of geodata. This started in 1999, which was long before INSPIRE [GDI-NW INFO]. That means INSPIRE was not the main impulse, the infrastructure would arise anyways. But the directive from 2007 pushed on the process obviously. Therefore INSPIRE should not be seen as an obligation but as a chance.

However there are still many ambiguities especially in the topic of pre-defined ATOM-Feed Download Services. The process of implementation is still running and some important documents are not yet finalized⁸ [GDI-DE KONV]. This thesis should help answering some questions. This chapter will take a closer look at the status quo in NRW by inspecting the GEOportal.NRW. Together with the technical requirements from chapter 4.2 this will be used to define requirements and criteria especially for NRW.

4.2.1 Functionality and Tools of GEOportal.NRW

The GEOportal.NRW⁹ is the central point of the spatial data infrastructure in North Rhine-Westphalia and also the central node for the INSPIRE implementation. General goals of the portal are implementation of the Geodata Access Act [GeoZG] requirements, providing a platform for electronic communication/ transaction/ interaction and providing access to geodata, network services and metadata.

Main elements are (see Figure 16):

- GEOportal (frame and user interface for underlying functionalities)
- GEOkatalog (metadata catalog, see chapter 2.3.2)
- GEOviewer (visualizes maps provided by Geobasis NRW, several layers possible: e.g. aerial photos, DGM, administrative units, external WMS services)

⁸ Current state 11.2014

⁹ <https://www.geoportal.nrw.de/>



Figure 16: Navigation bar of GEOportal.NRW [Screenshot]

Additionally the user can retrieve information and recent news about INSPIRE, GDI-DE, GDI-NW and other related topics. However the most relevant part for the thesis is the GEOkatalog.

It is important to note that the GEOkatalog.NRW is not a database for geodata, but a central point for the infrastructure, so to say the entry point to the electronic network. It is a source of information for beginners as well as for experts because of the intuitive user interface and profound functionality. Data provider have the possibility to register and manage metadata. Customers can search for this metadata and visualize WMS services on the map.

With regards to INSPIRE the geoportal is ready for Discovery Services. The GEOkatalog.NRW provides the necessary operations for the registration of metadata about network services. Furthermore the catalog is ISO conformant and provides a working OGC CSW 2.0.2 interface. Now it is on the data providers to publish interoperable INSPIRE Network Services.

Summarized following are the main functions for users, extracted from the specification document [GDI-NW]:

- Research: searching, based on geodata and metadata
- Visualization of services: visualization of geographic information
- General information: providing information about INSPIRE, GDI-DE and more
- Administration of metadata: registration and administration of metadata
- Login: authentication of users
- User management: decentralized administration of user rights
- Reporting: providing information about usage intensity of services
- Administration of the geoportal: maintenance of the general information

4.2.2 Architecture of GEOportal.NRW

For the further research it is important not just to look at functionality and outer appearance but also on the underlying architecture. The geoportal is realized by integrating several application into a basic structure. The elements are implemented with different software solutions and developed by different stakeholders. See Figure 17 and 18 for an overview of technologies, components, interactions and responsible stakeholders. Blue outlined stands for con terra, red for IT.NRW and green for Geobasis NRW – the three main stakeholders.

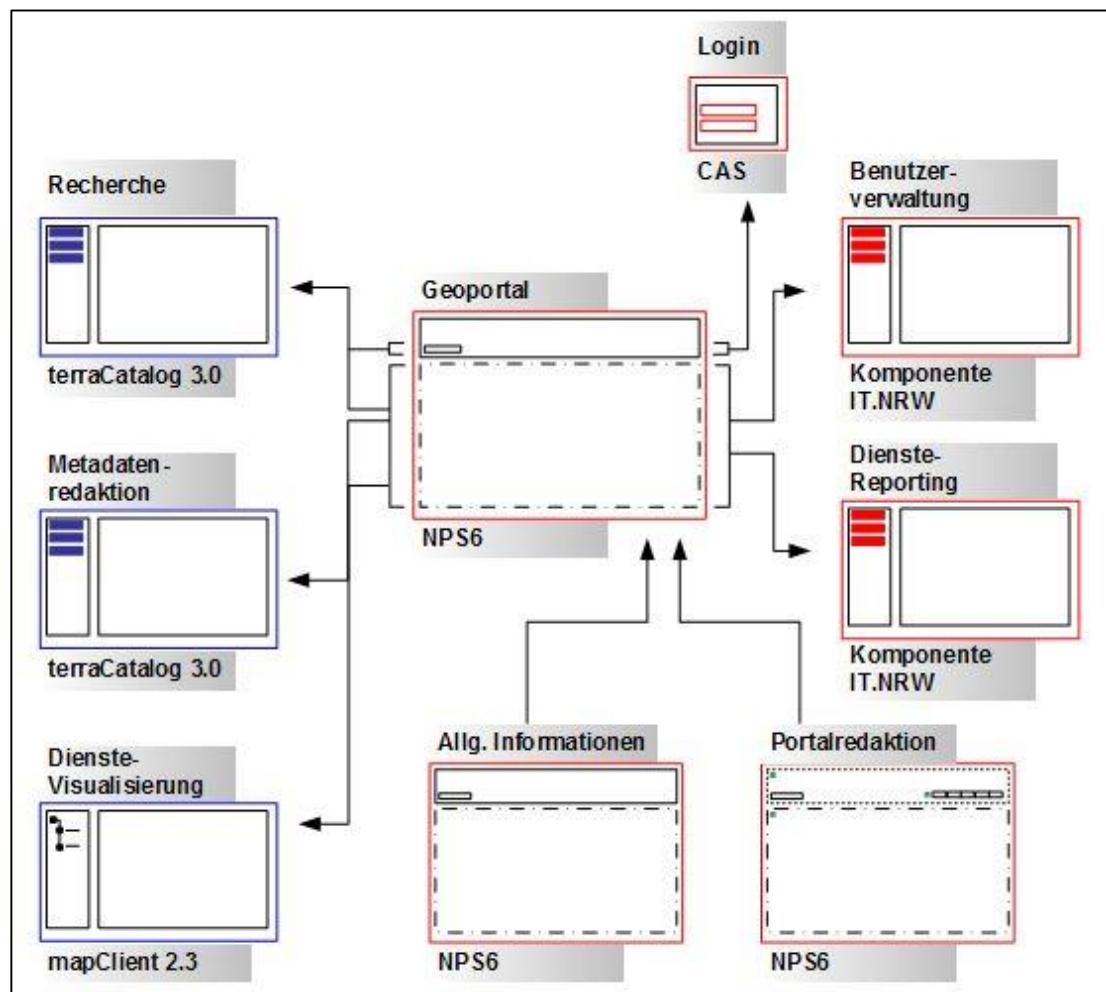


Figure 17: Functional Components of GEOportal.NRW [GDI-NW]

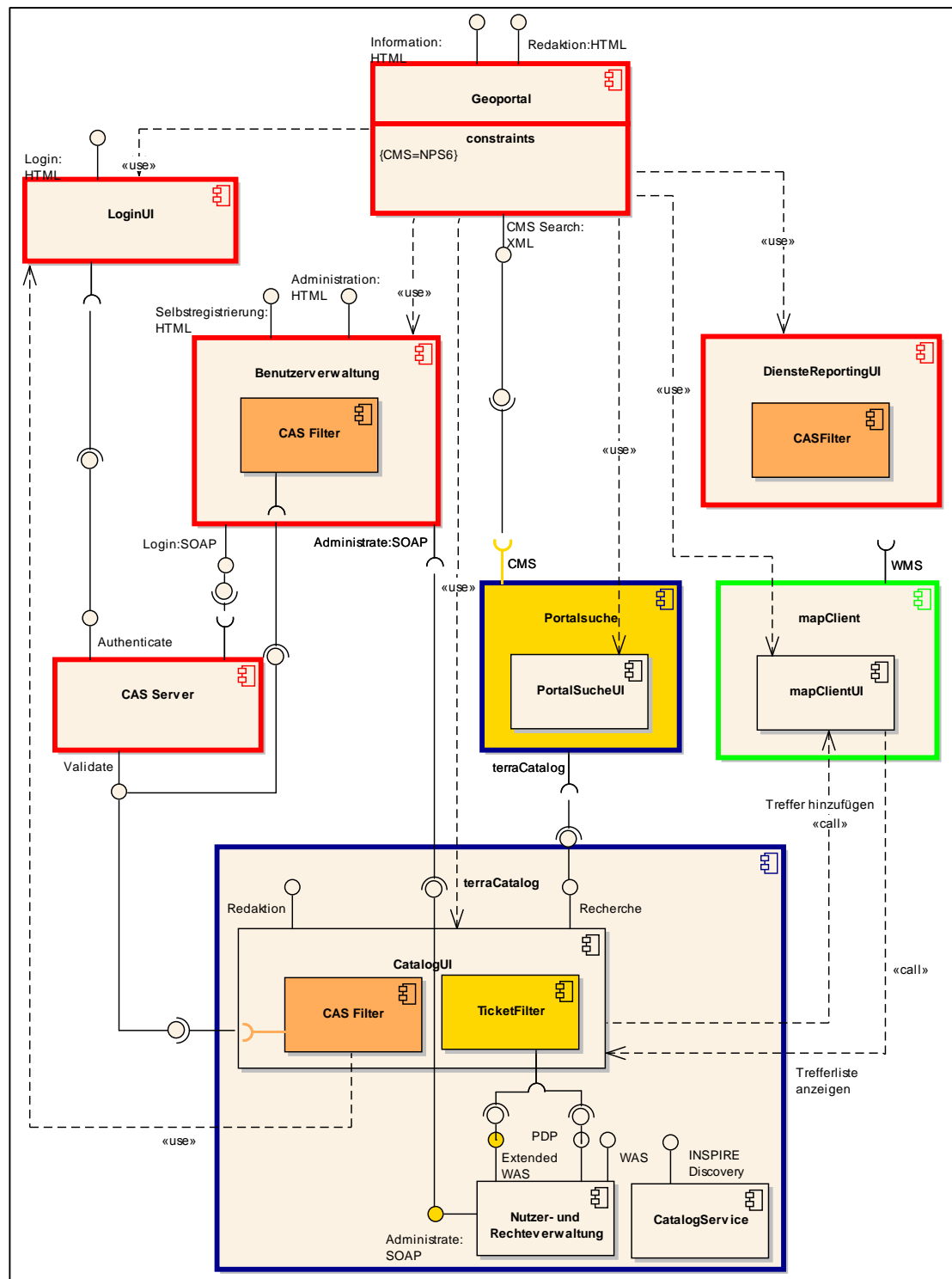


Figure 18: System architecture of GEOportal.NRW [GDI-NW]

Components of the geoportal are (see chapter 4.2.1): research, visualization of services, general information, administration of metadata, login, user management, reporting and geoportal administration. Following web applications are used for the implementation of the components:

- LoginUI: providing a HTML-based interface for insertion of user name and password
- Benutzerverwaltung (User Management): provides HTML-based interface for registration and administration of user accounts and user rights
- DiensteReportingUI (Service Reporting): offers requesting information about usage intensity of services
- mapClientUI: allows visualization of WMS services
- CatalogUI: provides HTML-based interface for search and maintenance of metadata about geographic resources
- PortalSucheUI: provides search functionality for the whole geoportal including metadata, information and news

The outer frame of portal is implemented with the Content Management System (CMS) NPS6/Fiona. The other applications are integrated into the frame via HTML iframes. All elements that relate to the metadata catalog are provided by con terra with help of the software terra.catalog 3.0.¹⁰ Visualization of WMS is done by map.client 2.3, also from con terra. From a WMS entry in the catalog it is possible to directly request a visualization with map.client. Components for login, user management and reporting were developed by IT.NRW and integrated into the architecture.

4.2.3 Future plan

The implementation of INSPIRE in NRW is still at the beginning. Especially the topic ATOM-Feeds raises a number of questions in top-level regional authorities as well as in the small communes. In order to support the communes in NRW it is planned to provide a tool for automated generation of ATOM-Feeds in near future. This tool should not be integrated directly into the architecture, but represent an independent solution. See the following chapter for requirements of such a solution. Possible realization alternatives are demonstrated in chapter 6.

¹⁰ The software was renamed to sdi.finder.

4.3 Requirements for NRW

Following requirements were identified in consultation with regional authorities of North Rhine-Westphalia, first the functional (1-4) then the technical requirements (5-7).

Requirements

1. A tool for the generation of ATOM-Feeds for pre-defined INSIPRE Download Services is to be provided. Following use-cases should be supported:
 - a. Generation on basis of dataset metadata with link to source
 - b. Generation on basis of existing Service-Metadata
 - c. Packing of WMS/WFS with help of metadata and data-service-coupling
2. The tool should be freely available as an independent online solution for supporting the communities in NRW.
3. The tool should be to some extent configurable in order to be flexible for possible changes of requirements.
4. ATOM-Feeds should be integrated into the geoportal
5. Generated Feeds must be correct and complete and fulfil
 - a. Technical guidance: Network Service
 - b. Implementing Rules: Network Services
 - c. Handlungsempfehlung GDI-DE (best-practice guide)
6. Feeds must consist of Service-Feed, Dataset-Feed(s) and OpenSearch-Description, linked with each other.
7. Following operations must be provided:
 - a. Get Download Service Metadata
 - b. Get Spatial Dataset
 - c. Describe Spatial Dataset
 - d. Link Download Service

Comments

To 1: see chapter 4.1.3

To 2: Integration into existing systems is very difficult because of the variety of different solutions and data formats → independent tool

To 3: Structure of GEOkatalog.NRW will remain, because it is an ISO conformal catalog. But the assignment of metadata attributes may change after release of the new version of the conventions document [GDI-DE KONV] → configurability

To 4: Type of integration of ATOM-Feeds in geoportal not yet cleared, the discussion of stakeholders still runs

To 5: not only requirements of the European Commission have to be fulfilled, but also the characteristics of NRW must be considered

To 6 and 7: see 4.1.1.1 and 4.1.1.2

4.4 Criteria for Evaluation

Based on the presented requirements and the status quo in NRW several aspects must be considered for an evaluation of the software solutions and realization alternatives.

- Presenting location for ATOM-Feeds
Is there a separated area for ATOM-Feeds or are they just registered as services in the metadata catalog?
- Dynamic generation vs. static storage
Are the ATOM-Feeds generated dynamically or permanent stored on the webserver?
- Basis of generation
Is the generation of ATOM-Feeds based on metadata or does the tool follow a different approach?
- User-friendliness
Is the software easy to handle? Is there a user interface?
- Integration of the tool into GEOportal.NRW
Is it necessary to integrate the tool into the existing architecture or is it an independent application?
- Open source
Is the software free and developable?
- Effort
How much effort is necessary to customize and integrate the solution?

5 Analysis of Existing Technologies

Before analyzing realization alternatives it is necessary to look at existing software solutions and existing implementations. This chapter will first introduce technologies and in the next step show how other institutions handle ATOM-Feeds with the mentioned software tools. The results will be used in chapter 6 in combination with requirements in order to develop a concept and propose realization alternatives.

5.1 Existing Software Solutions

There are several tools that support working with ATOM-Feeds. These software solution have conceptual and functional differences, therefore a classification takes place at the beginning. Relevant functions of identified software tools are as follows: generation, publication, visualization and download of ATOM-Feeds. Another criteria is the question about free licensing, thus open source. See Table 4 for an overview of the classification. In the following every solution will be investigated in order to highlight their characteristics and detect possible handicaps.

Table 4: Classification of Software Solutions

| Software | Gene-ration | Publi-cation | Visuali-zation | Download | Open Source |
|----------------------|-------------|--------------|----------------|----------|-------------|
| ATOMFeedGenerator | X | X | (X) | X | X |
| Mapbender | X | X | X | X | X |
| FME ¹¹ | X | | X | X | |
| ArcGIS ¹² | | X | X | X | |
| QGIS ¹³ | | | X | X | X |
| Google Maps | | | X | | X |
| Browser | | | X | X | X |

¹¹ + INSPIRE Solution Pack

¹² + ArcGIS for INSPIRE

¹³ + INSPIRE ATOM Client

5.1.1.1 ATOMFeedGenerator

First software in the list is the ATOMFeedGenerator, a Java Web Application developed by Mathias Lückner and Michael Räder for MDI-DE in Lower Saxony. The open-source product is freely available on the web.¹⁴ Once the application is deployed in Tomcat it is possible to generate INSPIRE pre-defined ATOM-Feeds based on standard conformal metadata [AFG]. Necessary attributes are assigned to the program via a configuration file. Mandatory attributes are link to the CSW interface and list of IDs for the concerned metadata records. Optional attributes are e.g. proxy and storage paths. They receive standard values, if nothing is entered. See Table 5 for the full list.

Table 5: Attributes for the ATOMFeedGenerator

| Attribute | Mandatory | Optional | Comment |
|----------------|-----------|----------|---|
| cswURL | X | | Link to CSW interface of the catalog, e.g.: http://numis.niedersachsen.de/202/csw? |
| serviceUUIDs | X | | IDs of the metadata records in the catalog, that will be transformed - must be Service-Metadata |
| proxyHost | | X | Name of Proxy |
| proxyPort | | X | Port of Proxy |
| feedURL | | X | URL of the web application |
| servicePath | | X | Storage path of Service Feeds |
| dataSetPath | | X | Storage path of Dataset Feeds |
| opensearchPath | | X | Storage path of OpenSearch Description |
| cronStart | | X | Starting time of the application |
| key | | X | Key for starting the manual generation |
| startDelay | | X | Delay for starting the generation |
| transOpt | | X | 'new' vs. 'old' generation method |

After starting the Tomcat webserver the application reads the properties of the configuration file and starts a getRecordById-Request (see chapter 2.3.1). The received XML document is stored and the necessary attributes are extracted with

¹⁴ https://www.mdi-de.org/downloads/atomFeedGenerator_2.0.zip

XPath.¹⁵ The extracted attributes are written into Service-Feed, Dataset- Feeds and OpenSearch Description Documents.¹⁶ Together with an OpenSearch script they are published in the web application. Access to the feeds is provided as defined in the technical guidance over OpenSearch requests. An example of the implementation can be found on the site of MDI-NI.¹⁷ As visible in Figure 19 the page has three elements:

- Drop-Down-List for selecting a Download Service
- List of datasets of the selected Download Service
- List of all available Service Feeds

| Detail | Titel des Datensatzes | Projektion (EPSG-Code) | Ausgabeformat | Datenoriginator | Identifikator |
|--------|--|------------------------|-------------------------|---|----------------------------------|
| ✓ | Erfassung des Schweinswalbestandes im niedersächsischen Küstenmeer 2008 (UTM) | 31467 | application/x-shapefile | Nationalparkverwaltung Niedersächsisches Wattenmeer | 4028478a1d04a5d2011d0a6b372f000f |
| ✓ | Erfassung des Schweinswalbestandes im niedersächsischen Küstenmeer 2008 (WGS84) | 25832 | application/gml+xml | Nationalparkverwaltung Niedersächsisches Wattenmeer | 4028478a1d04a5d2011d0a6b372f000f |
| ✓ | Erfassung des Schweinswalbestandes im niedersächsischen Küstenmeer 2010 (UTM) | 31467 | application/x-shapefile | Nationalparkverwaltung Niedersächsisches Wattenmeer | ff8081812d73f5f3012d83e34ff40005 |
| ✓ | Erfassung des Schweinswalbestandes im niedersächsischen Küstenmeer 2010 (WGS84) | 25832 | application/gml+xml | Nationalparkverwaltung Niedersächsisches Wattenmeer | ff8081812d73f5f3012d83e34ff40005 |
| ✓ | Erfassung des Eiderentenbestandes im niedersächsischen Wattenmeer im Frühjahr 1991 | | | Nationalparkverwaltung | |

Figure 19: ATOMFeedGenerator Web Client [Screenshot]

By clicking on a listed dataset the user gets information about the dataset in form of a preview image and the geographical extend. It is remarkable that the INSPIRE relevant datasets are all concentrated here in the client of the web application. That means INSPIRE pre-defined ATOM-Feeds get an own section on the website, they are not directly integrated into the geoportal.

The application works error-free and fast (generates an ATOM-Feed in several seconds) for the metadata catalogs in Lower Saxony. But it does not work on the GEOkatalog.NRW. The ATOMFeedGenerator was fitted on NOKIS and NUMIS of MDI-NI¹⁸, which have special characteristics. That means it is not simply portable to

¹⁵ XPath stands for XML Path Language, it is a query language for analyzing XML documents.

¹⁶ See [AFG] for detailed attribute mapping

¹⁷ <http://mdi.niedersachsen.de/atomFeed/>

¹⁸ <http://www.nationalpark-wattenmeer.de/nds/service/geodatenportal>

NRW or other catalogs, it needs special customization and implementation, which is not part of the thesis. Another important aspect is the requirement of Service-Metadatas. The ATOMFeedGenerator needs metadata that keeps information about coupled resources (see chapter 4.1.2).

5.1.2 Mapbender

In contrast to the ATOMFeedGenerator Mapbender is not an independent application covering a special use case. Rather it is a big development environment for map applications written in PHP and JavaScript, ATOM-Feeds are just a small part of it. In simple terms Mapbender is an open source Content Management System (CMS) reading out geodata dynamic from a database. It does not contain maps itself, but it can display any existing interoperable service. Due to the easy integration with existing architecture and websites it is often used as software for geoportals. Summarized Mapbender covers the following topics [MAPBENDER]:

- Web-GIS Client (OGC WMS, WFS, Catalog Service Client)
- Geo-CMS (Content Management System)
- Web-based Digitizing/Editing Functionality (OGC WSF-T Client)
- Security Management (Authentication, Authorization)
- Accounting Management (Logging)
- Spatial Web Services Orchestrating

In terms of INSPIRE pre-defined Download Services Mapbender provides the possibility to dynamically generate ATOM-Feeds from ISO metadata. Three use cases are supported:

- Generation based on WMS data sources
- Generation based on WFS data sources
- Generation based on ISO 19139 metadata

Mapbender generates pre-defined INSPIRE Download Services automatically 'on-the-fly'. The PHP scripts that realize this method are freely available at [1]¹⁹ and [2]²⁰.

¹⁹

[http://trac.osgeo.org/mapbender/browser/trunk/mapbender/http/php/mod_inspireAtomFeedISO
OMetadata.php](http://trac.osgeo.org/mapbender/browser/trunk/mapbender/http/php/mod_inspireAtomFeedISOMetadata.php)

²⁰

[http://trac.osgeo.org/mapbender/browser/trunk/mapbender/http/php/mod_inspireDownloadF
eed.php](http://trac.osgeo.org/mapbender/browser/trunk/mapbender/http/php/mod_inspireDownloadFeed.php)

Script [1] creates the necessary Service-Metadata and script [2] generates ATOM-Feeds and the OpenSearch Description Document. The availability of the scripts does not imply the possibility of a simple adoption of the concept. The situation is quite the contrary. The solution is based on the principle of a central administration with Mapbender as a Service-Registry. Taking over the scripts would imply the adoption of the whole system. See chapter 5.2.1 for more information about the portability of this idea. In short, an implementation of this idea would cost lot of effort. Similar to the ATOMFeedGenerator the concept of Mapbender is not easily applicable to other institutions.

A central element of the INSPIRE implementation with Mapbender is the 'INSPIRE Download Service ATOM Feed Client' that is usable independently as well²¹. The HTML based web application provides functionality for visualization of feed information and download of the underlying datasets.

Example request:

http://www.geoportal.rlp.de/mapbender/plugins/mb_downloadFeedClient.php?url=http%3A%2F%2Fwww.geoportal.rlp.de%2Fmapbender%2Fphp%2Fmod_inspireDownloadFeed.php%3Ffid%3D9d05f710-1ea1-5a97-60d3-7cca03e800ce%26type%3DSERVICE%26generateFrom%3Dwmslayer%26layerid%3D35204

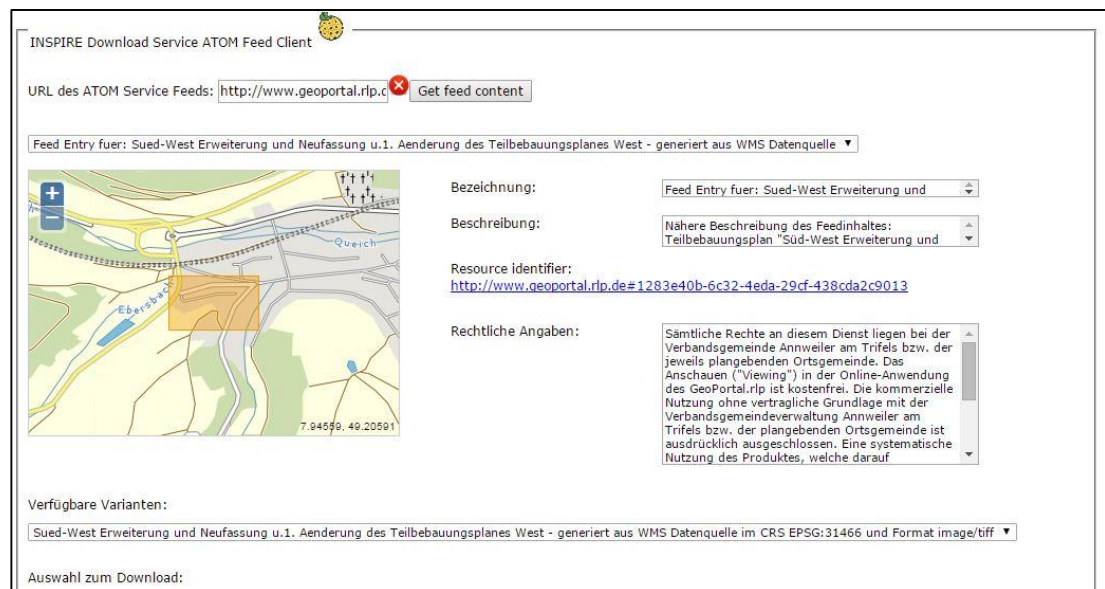


Figure 20: Mapbender ATOM-Feed Client [Screenshot]

²¹ http://www.geoportal.rlp.de/mapbender/plugins/mb_downloadFeedClient.php

5.1.3 ArcGIS

ArcGIS is one of the leading geographic information systems (GIS) worldwide. It is developed in USA by ESRI, the recent version is 10.2.2. ArcGIS provides a powerful solution for the implementation of INSPIRE. 'ArcGIS for INSPIRE' extends the ArcGIS Server functionality by providing:

- INSPIRE View Services
- INSPIRE Download Services
- INSPIRE Discovery Services
- INSPIRE Data Models

Important point here is the INSPIRE Download Service. Both possibilities of publication are available: direct-access WFS and pre-defined ATOM-Feed. For providing INSPIRE predefined dataset ATOM-Feeds an existing Service-Feed is necessary. That means the software cannot generate new feeds, they must be already available. But it can use existent feeds in order to provide conformal INSPIRE Download Services. See Figure 21 for the workflow of publication in ArcGIS Server. After publication the feeds are accessible either through REST page (see Figure 23) or directly through the OpenSearch endpoint (see Figure 22) [ARCGIS].

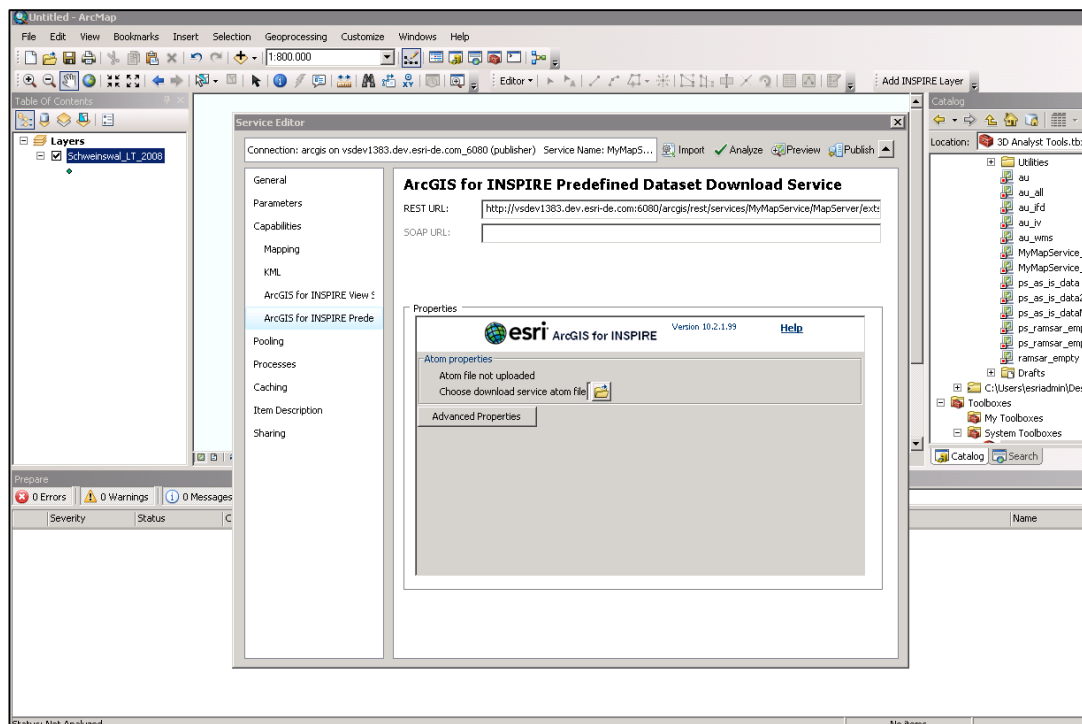


Figure 21: Publication of INSPIRE Download Services with ArcGIS for INSPIRE [Screenshot]

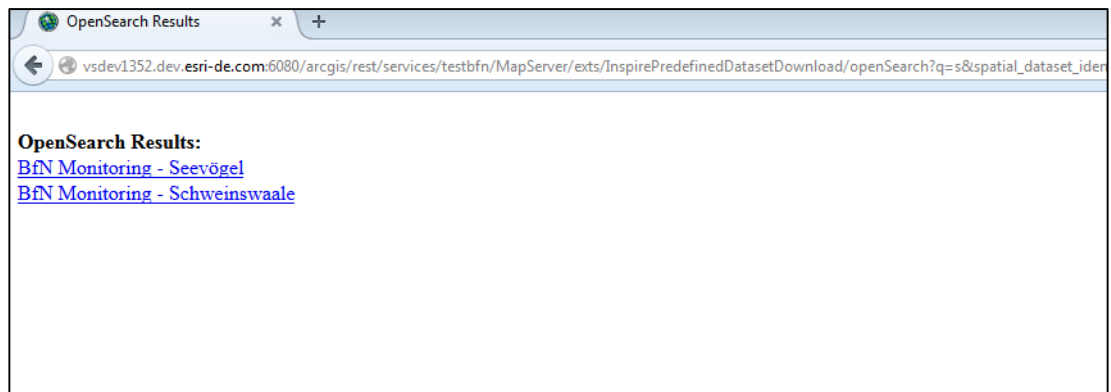


Figure 22: Accessing ATOM-Feeds with OpenSearch, provided by ArcGIS [Screenshot]

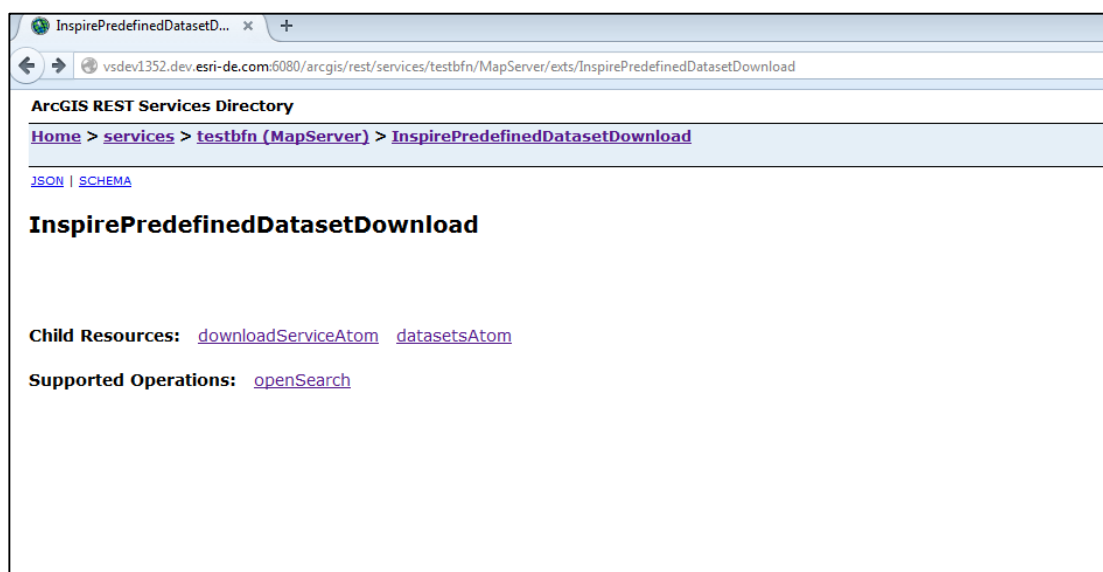


Figure 23: Accessing ATOM-Feeds with REST, provided by ArcGIS [Screenshot]

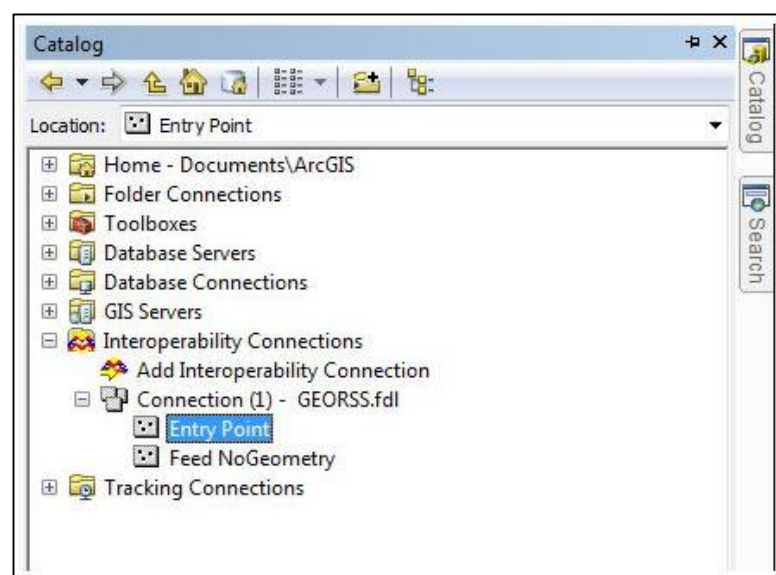


Figure 24: ArcGIS Interoperability Connection for consuming GeoRSS [ESRI]

A tool for visualizing or working with ATOM-Feeds is not directly integrated in ArcGIS. The only possibility to present the spatial information of a feed is to use the Interoperability Connection (see Figure 24) for consuming the GeoRSS information from a feed [ESRI]. There is no extension that is able to interpret the link-elements inside the ATOM-Feeds and to analyze underlying data. The dataset are not directly accessible, even if the data is in a supported format (e.g. SHP).

5.1.4 FME

FME (Feature Manipulation Engine) is a spatial ETL tool for data transformation. ETL stands for the terms Extract, Transform and Load, which describes the functionality of FME very well. The software is developed by the company Safe Software Inc. from Canada, the distribution in Germany is managed by the con terra GmbH. FME supports the accessing, processing and outputting of over 300 formats, e.g. GML, SHP, DXF and GeoRSS.²² Due to the intuitive user interface and the 'Drag-and-Drop' controlling working with FME is very user-friendly and not just a tool for experts and developers. However FME is a very powerful tool within spatial data infrastructures.

FME is available as Desktop and Server edition. The basic software application FME Desktop include capabilities for the transformation and visualization of spatial data. With help of the intuitive 'point-and-click' graphic interface FME Workbench a flow of data is visualized, including Reader, Writer and Transformer. Actually 365 different formats for input and output are supported by FME.

The INSPIRE Solution Pack is an extension for FME providing pre-build workspaces for the transformation of data into the INSPIRE Data Model. Templates are currently available for the Annex I themes, the other topics are in progress.²³ Target output schema is an ESRI Geodatabase with the goal of publishing the INSPIRE conformal data as INSPIRE Services with help of ArcGIS for INSPIRE. As mentioned the main tasks of FME are data harmonization and transformation. However due to the existing support of XML, GeoRSS Feeds and CSW requests it is also possible to generate ATOM-Feeds based on Service-Metadata. In this case the output is not a Geodatabase, but a GML document (INSPIRE GML²⁴) ready for publication. A workspace for this use case is in development and will be available in the next release

²² <http://www.safe.com/fme/format-search>

²³ Current state 11.2014

²⁴ http://fmepedia.safe.com/articles/How_To/INSPIRE-GML

of the INSPIRE Solution Pack. See Figure 25 for a preliminary version of the workspace.

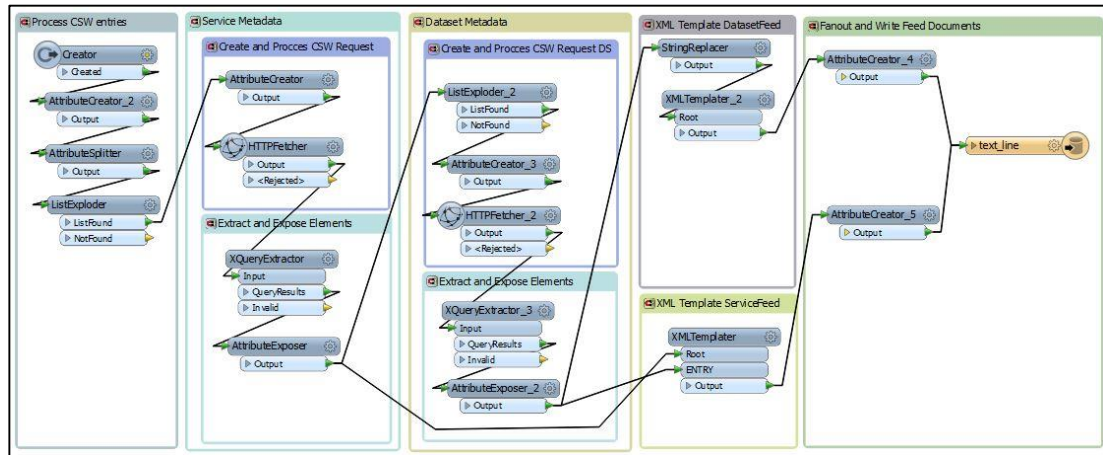


Figure 25: FME INSPIRE Solution Pack. Workspace for generation of ATOM-Feeds [Screenshot]

Datasets can be visualized with the FME Data Inspector, a fix component of FME. Similar to a GIS the tool can display different data formats and visualize different levels of layers. ATOM-Feeds are one of the supported formats. The tool is able to list the feed entries in a table, display the download links to Dataset-Feeds and visualize the GeoRSS content on the map.

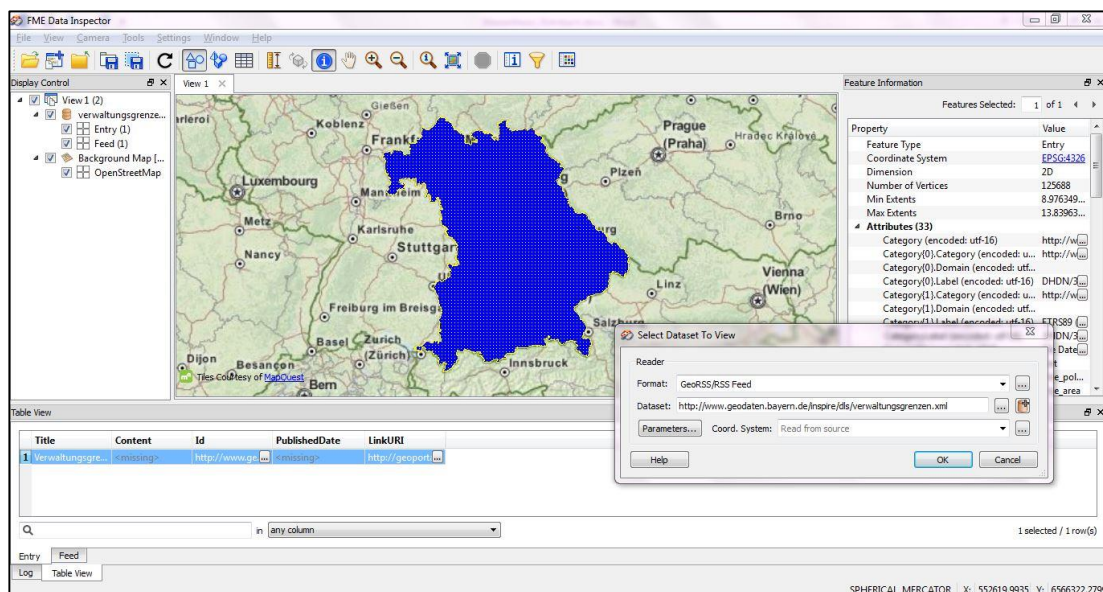


Figure 26: FME Data Inspector, visualizing an INSPIRE Atom-Feed [Screenshot]

The combination of ArcGIS for INSPIRE and INSPIRE Solution Pack for FME is a well-thought-out solution for the implementation of INSPIRE Download Services. The whole workflow from data transformation to the publication of interoperable Download Services can be executed. Big advantage of this method is the user friendliness of the software tools. Both software solutions are possibly limited in working with ATOM-Feeds, but together they can cover the whole workflow (see Figure 27).

Another interplay of components is imaginable: In combination with FME Server a whole ATOM-Feed lifecycle from generation to publishing is possible. FME Server can provide the transformations mentioned above as services in a network or in the web and provide methods for the upload of datasets and feeds.²⁵ See chapter 6.1 for possible realization alternatives.

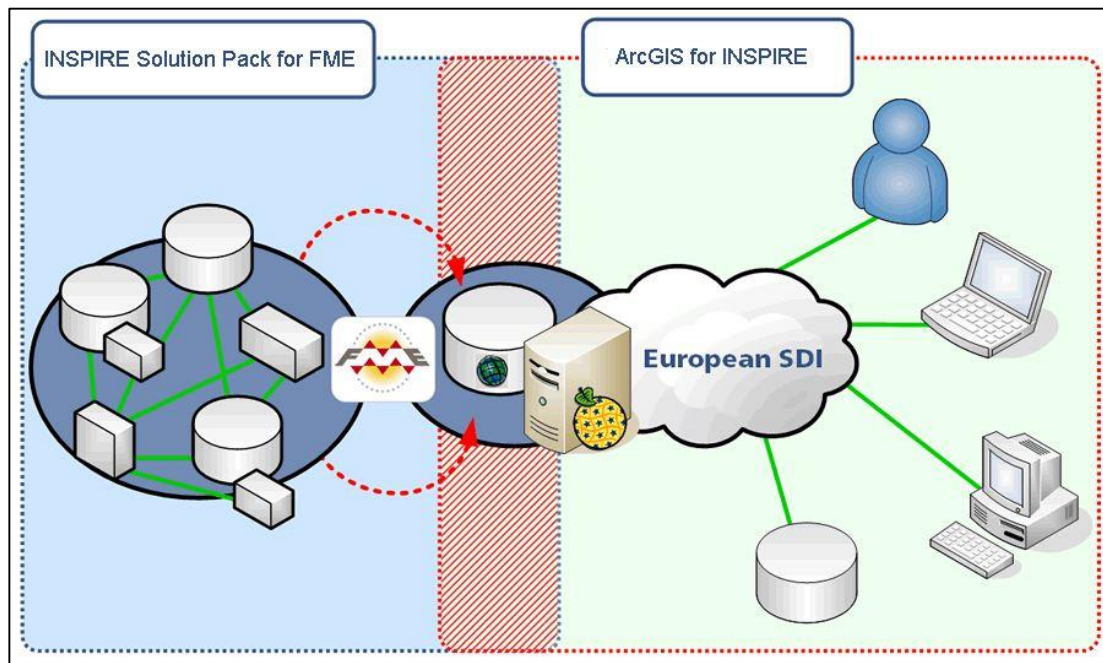


Figure 27: FME INSPIRE Solution Pack and ArcGIS for INSPIRE as overall solution [CON TERRA]

5.1.5 QGIS

An alternative for ArcGIS is the open source solution QGIS. It is a cross-platform desktop GIS application that provides data viewing, editing and analysis capabilities. Characteristics of QGIS are on the one hand the integration of other open source packages like PostGIS, GRASS and MapServer. On the other hand it is possible to

²⁵ Exemplary implementations with FME Server: <http://playground.fmeserver.com/demos/>

extend the functionality by plugins written in Python and C++. One of these plugins, the ATOM-Feed Client, provides the functionality of working with ATOM-Feeds. By entering the link to a Service-Feed it is possible to visualize the data and import it into the GUI of QGIS. Users can also download the available datasets or inspect the metadata. The plugin was developed by Jürgen Weichand for his master thesis in 2012 (see chapter 3) [WEICHAND AFC]. Disadvantage is the non-conformity to the latest releases of QGIS. Versions above 2.x does not support the plugin, however Figure 28 shows the usage within QGIS 1.8.

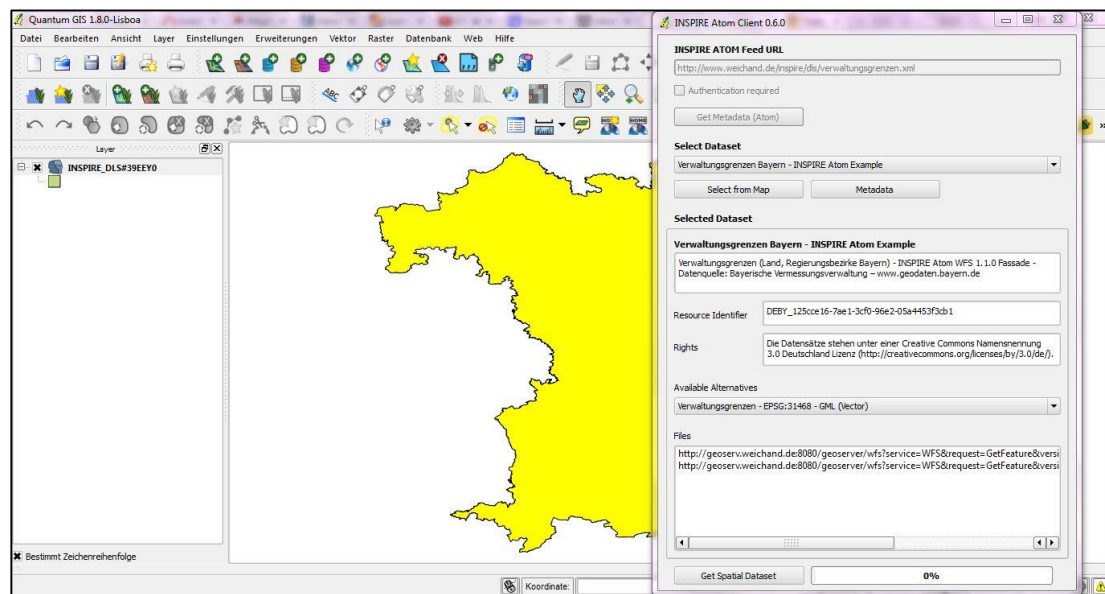


Figure 28: ATOM-Feed Client for QGIS [Screenshot]

5.1.6 Google Maps

Another web client supporting the visualizing of ATOM-Feeds is Google Maps. By inserting the link to a Service-Feed into the search form, it is possible to present the extent on the map. Precondition is the existence of GeoRSS or GML elements in the feed. An example of a GeoRSS-Feed is shown in chapter 2.4.2. For a GML example see Figure 29. It demonstrates that the application can handle even a big amount of data.²⁶ For a simple example with square bounding box see following link:

²⁶ https://maps.google.de/maps?q=http://rs211980.rs.hosteurope.de/ao-csw-umarf/servlet/eopos?bbox%3D-170.00,-170.00,140.00,80.00%26dtstart%3D2011-08-01%26dtend%3D2011-08-02%26pl%3Durn:ogc:def:EOP:EUM:acronym:ASCxxx1A:satellite:M02:fileid:EOP:EUM:DAT:METOP:ASCSCO1B%26sl%3D1%26c%3D3&bav=on.2.or.r_cp.r_qf.&bvm=bv.80185997.d.ZWU&biw=1366&bih=643&dpr=1&um=1&ie=UTF-8&sa=X&ei=jBjxVJbTK4qxadjagOAP&ved=0CAcQ_AUoAg&output=classic&dg=feature

<https://maps.google.de/maps?q=http://gis.stmk.gv.at/inspire/downloadservice/DownloadServiceFeed.xml>

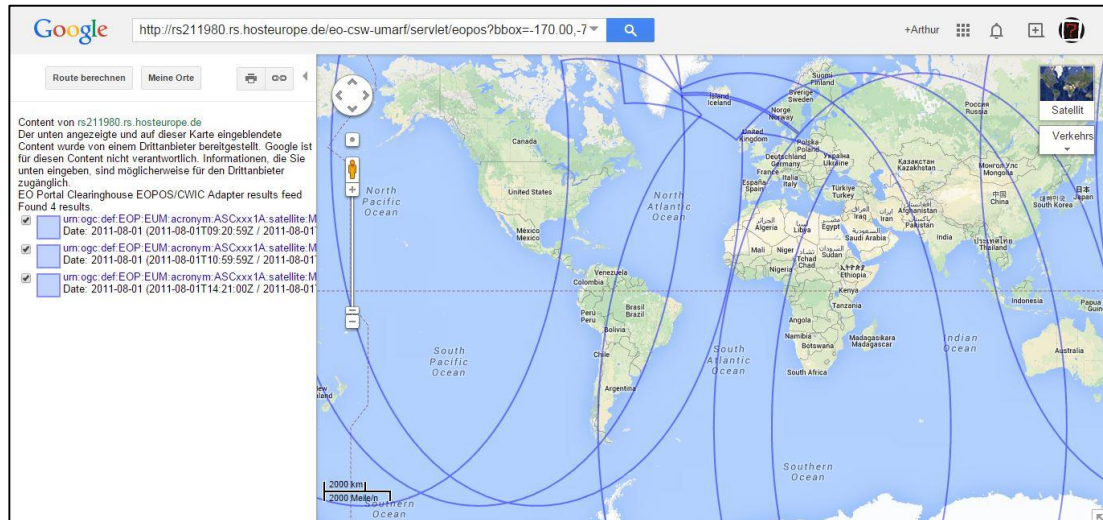


Figure 29: Visualization of an ATOM-Feed with Google Maps [Screenshot]

The handicap of Google Maps is the limitation to top-level Service-Feeds. It is not possible to access the underlying Dataset-Feeds because the application is not able to identify the 'link' elements that point to the datasets. The Service-Feed refers to several links like metadata or Dataset-Feeds, but Google cannot resolve these INSPIRE specific definitions. For the same reason a download from the Google Maps user interface is also not possible.

That means Google Maps is limited in working with ATOM-Feeds. However it is a good tool for visualizing the extent of a dataset on the map, but unsuitable for presenting or downloading the data itself.

5.1.7 Net Browser

A simple method for presenting ATOM-Feeds are common net browsers. This is comprehensible because Feeds are in XML format. Every browser can interpret XML, but the style of presenting ATOM-Feed can differ greatly. The behavior of the most popular browsers²⁷ will be investigated: Chrome, Mozilla Firefox, Internet Explorer, Opera and Safari. The two main criteria for differentiation and evaluation are

²⁷ <https://www.browser-statistik.de/>

subscribing and presentation of feeds. Testing object is the exemplar ATOM-Feed of the JRC, the link was simply inserted into the address box of the browser:

<http://inspire-geoportal.ec.europa.eu/demos/ccm/democcmdownloadservice.atom.en.xml>

During investigation it became quickly clear that the browsers can be classified in two groups:

- Group 1: Firefox, Internet Explorer, Safari – good handling of ATOM-Feeds
- Group 2: Chrome, Opera – no support of ATOM-Feeds

Members within a group handle ATOM-feed very similar, therefore from this point we only talk about them summarized as group 1 or 2. Group 2 does not provide a presentation method for ATOM-Feeds, the XML code is just shown without any visualization. By contrast group 1 offers a clearly arranged presentation of the example feed. The preview image is shown as well as links the datasets and brief descriptions. The arrangement of elements is similar in all three alternatives. Safari and Internet Explorer additionally have a navigation bar on the right side. The second use-case, subscription of feeds, is provided by both groups, even if group 2 requires additional installation of plugins or extensions in order to enable the functionality. See Figure 30 for group 1 and Figure 31 for group 2. Table 6 summarizes the results.

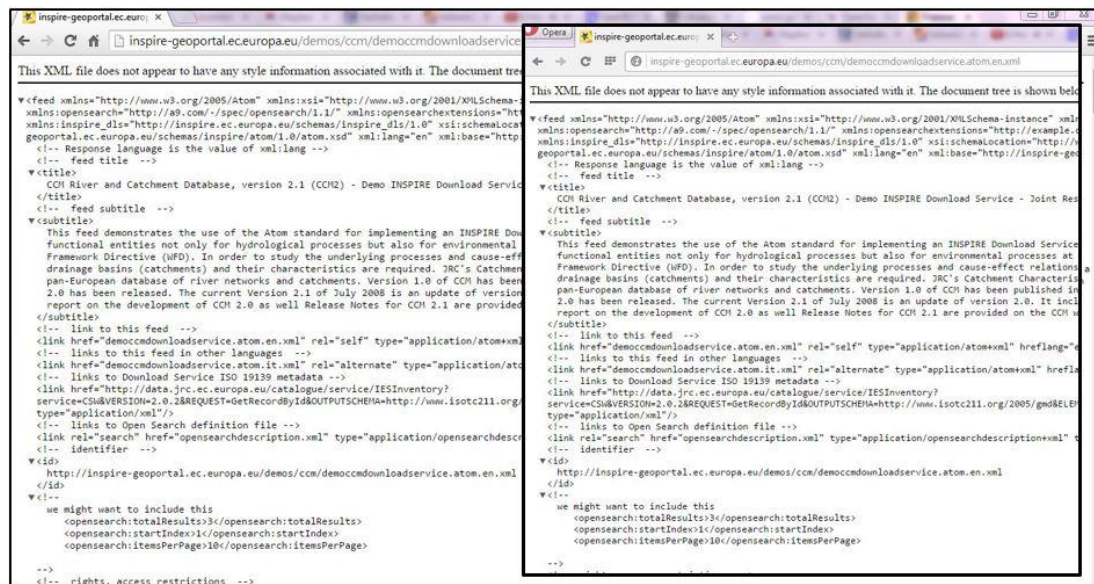


Figure 30: Chrome (left) and Opera (right) [Screenshots]

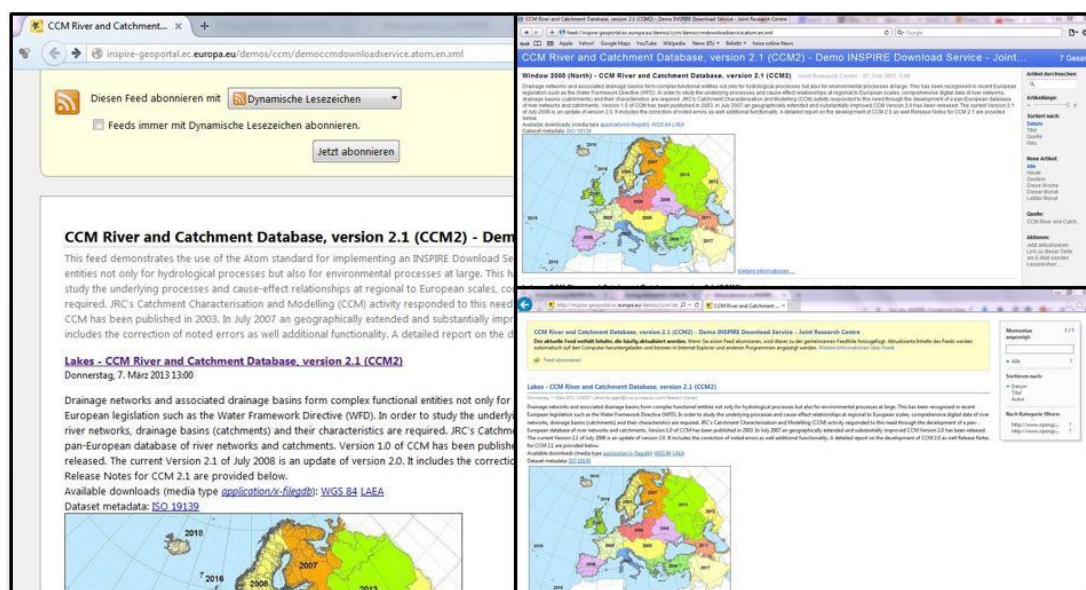


Figure 31: Firefox (left), Safari (top right) and Internet Explorer (bottom right) [Screenshots]

Table 6: ATOM-Feed conformity of actual net browsers

| Browser | Presentation | Suscription |
|-------------------|-----------------|--------------------|
| Chrome | <i>XML only</i> | <i>with plugin</i> |
| Firefox | yes | yes |
| Internet Explorer | yes | yes |
| Opera | <i>XML only</i> | <i>with plugin</i> |
| Safari | yes | yes |

Summarized one can say that net browser are a good alternative to quickly inspect ATOM-Feeds. The best outer appearance and functionality has Safari, followed by IE and FF. However for closer inspection of feeds and data behind them it is recommended to use special ATOM-Feed Clients²⁸ or GIS software.²⁹

²⁸ See chapter 5.1.2 and 5.1.7

²⁹ See chapter 5.1.5 and 5.1.6

5.1.8 Validation Tools

For a consistent structure of the spatial data infrastructure the requirements of INSPIRE regarding the technical implementation must be fulfilled. Cross-border and area-wide usage of geodata requires interoperable services. There are several web applications available to test the conformity of metadata, View Services, Download Services and predefined ATOM-Feeds. Mainly there are two tools for validating INSPIRE pre-defined ATOM-Feeds, the INSPIRE Validator³⁰ on European level and the GDI-DE Testsuite³¹ on national level of Germany. For the sake of completeness the validator of the state level, the GEOkatalog.NRW, is also mentioned here, even if it supports only validation of metadata.

The GDI-DE Testsuite is the central validation tool for spatial data infrastructures and INSPIRE in Germany. Following testing functionalities are available:

- ISO Metadata, INSPIRE Metadata
- WMS 1.1.1, WMS 1.3.0
- INSPIRE View Service based on WMS 1.1.1
- INSPIRE View Service based on WMS 1.3
- INSPIRE Discovery Service 3.0
- OGC CSW 2.0.2
- INSPIRE Download Service Atom Implementation

Services can be registered with an URL, metadata in form of XML documents can also be uploaded on the user interface. After registration of test objects the test gets started. The user gets informed about the result via email, when the test is finished. The user interface of the validator is well-arranged and easily operated (see Figure 32). It is possible to download the whole application and use the GDI-DE Testsuite in a local environment.

³⁰ <http://inspire-geoportal.ec.europa.eu/validator2/>

³¹ <https://testsuite.gdi-de.org/gdi/>

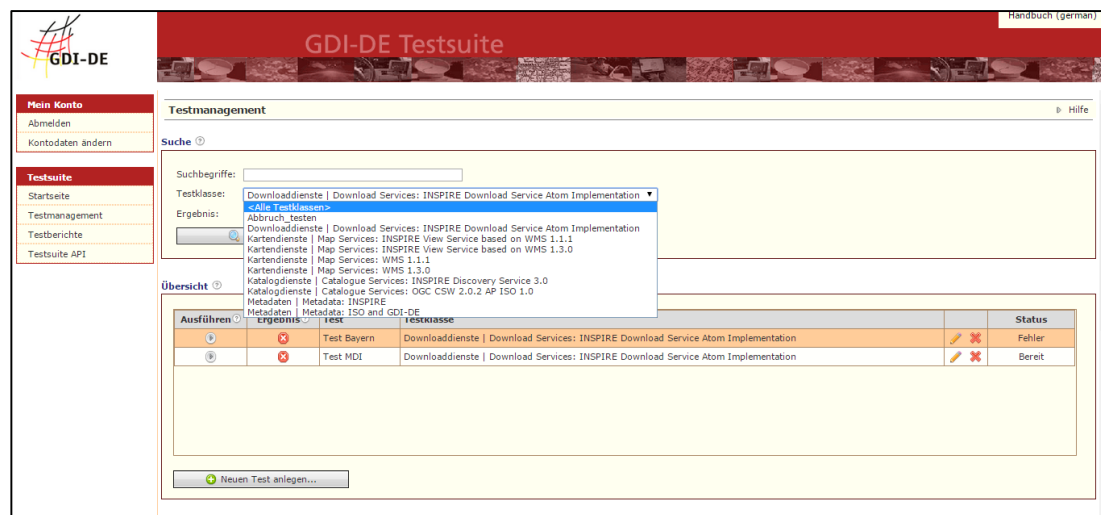


Figure 32: GDI-DE Testsuite [Screenshot]

The INSPIRE validator, the top level validator of the European Geoportal, is designed in a very simple manner. The HTML page consists of a form for registration of test objects, a button for uploading test documents and a short description (see Figure 33). The validator provides following testing classes:

- ISO Metadata
- Service-Metadata
- INSPIRE Download Service ATOM-Feeds

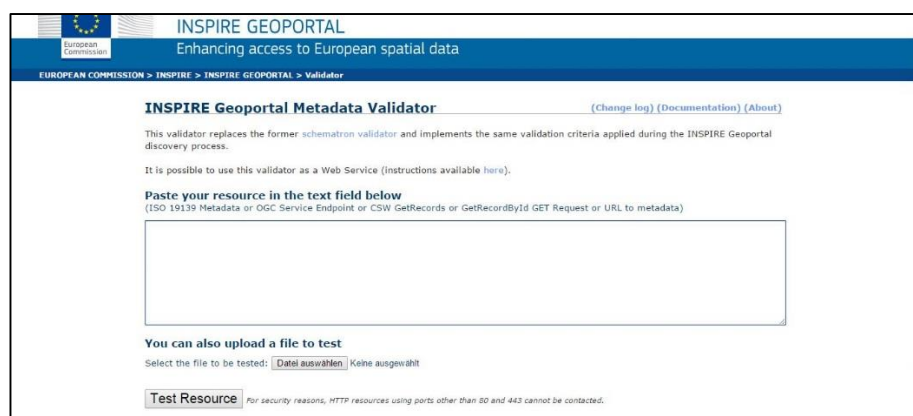


Figure 33: INSPIRE Validator [Screenshot]

Similar to the GDI-DE Testsuite the test object can be registered by an URL or an upload of the document. The result of the test is displayed immediately on a HTML page.

The validator on NRW level is integrated into the metadata catalog, the GEOkatalog.NRW. This tool validates the registered metadata and ensures that it complies the metadata profile of NRW. Non-conformal metadata is not accepted. That means wrong or incomplete metadata can't be published in the catalog. See chapter 2.3.2 for detailed information about the functionalities of GEOkatalog.NRW.

5.2 Existing pre-defined Download Services with ATOM-Feeds

Before analyzing realization alternatives it is important to look at existing implementations of other institutions and to check the applicability of the concepts to NRW. Mainly two implementations will be investigated: the Mapbender approach of Rhineland-Palatinate (RP) and the ATOMFeedGenerator of Lower Saxony (LS). Both solutions are characterized by their unique and special concept based on open source products. Due to their leading role in Germany in context of INSPIRE ATOM-Feeds it is necessary to take a closer look. The research will not go too much into detail, but it will briefly describe the concept and technologies in order to show a possible portability to NRW. The recent monitoring results³² underline the selection. Lower Saxony (9391) and Rhineland-Palatinate (319) reported most of the provided Download Services in Germany (11999). North Rhine-Westphalia has considerably less services (91) despite the large size and big population. The great number of reported services in RP is due to the type of data storage. In contrast to NRW dataset like 'Landschaftsschutzgebiete' in RP are provided as 46 sub-parts, one for every district. In this example that means one dataset in NRW corresponds to 46 datasets in RP [DÜRENa]. This data management is reason for the big number of reported Download Services. However apart from that Rhineland-Palatinate is many steps ahead in the implementation of INSPIRE.

5.2.1 Rhineland-Palatinate

Rhineland-Palatinate has a leading role in the implementation of INSPIRE in Germany. The area-wide providing of INSPIRE Network Services became possible because of the special concept. An INSPIRE-Proxy as central solution take over the

³² <http://www.geoportal.de/monitoring2013/>

work from the cities and communities by generating the INSPIRE Services 'on-the-fly'.

Technically the system of RP is built completely on open source solutions. The basis is Mapbender, assisted by MapServer and GeoServer for WMS/WFS functionality. The database is implemented with PostgreSQL and PostGIS Extension [GDI-RP AR]. The special thing is the usage of an 'INSPIRE-Proxy'. That means in case of a request for a service the proxy accesses the data (stored in old format, not INSPIRE conformal), transforms it on-the-fly and provides conformal INSPIRE View or Download Services to the customer. With this method RL can still use the old standards and anyhow fulfill the requirements of INSPIRE. Precondition is the existence of a well-defined SDI. Similar to the services all metadata and capabilities documents are generated at runtime, which solve the problem of data-service-coupling, too.

Due to this central solution data providers were not confronted with INSPIRE. Even the task of registration metadata were taken off by the top-level authority by storing metadata together with underlying datasets in PostGIS. The aim was making everything as easy as possible for the data providers [RETTERTHb]. That based on the assumption that data providers would anyway not manage the implementation of INSPIRE [RETTERTHb], which is a hard but realistic assessment. RP has 4 Million inhabitants distributed on 2300 communities. With an average population of 1740 it becomes clear that not every city is able delegate an INSPIRE expert for the INSPIRE implementation. So the central INSPIRE-Proxy is the most useful solution for RP.

As already mentioned the generation of ATOM-Feeds works 'on-the-fly' during runtime. Mapbender needs following information to dynamically provide ATOM-Feeds as Download Services: dataset metadata, dataset-service relation, dynamic getMap/getFeature URLs. The execution is done by PHP-scripts that read out dataset-metadata, create Service-Metadata, generate getMap/getFeature URLs and write the ATOM-Feeds and OpenSearch documents. This method also solves the problem of updating Download Services, it is only necessary to keep the metadata up-to-date.

Example request:

http://www.geoportal.rlp.de/mapbender/plugins/mb_downloadFeedClient.php?url=http%3A%2F%2Fwww.geoportal.rlp.de%2Fmapbender%2Fphp%2Fmod_inspireDownloadFeed.php%3Fid%3D6fd8a405-6463-3989-c87f-2a510c28a325%26type%3DSERVICE%26generateFrom%3Dwfs%26wfsid%3D292

All INSPIRE View and Download Services are registered in the central metadata catalog of RP. However by filtering the entries with the element 'inspireidentifiziert' it is possible to visualize an INSPIRE-only catalog. The necessary data is provided by a JSON web service and presented with the jQuery datatables library [MAPBENDER H].

| Detail | Titel | Identifikator | Organisation | INSPIRE Themen |
|--------|--|--|-------------------------|--|
| | Im Gerstengarten i.d.F. der 1. Änderung 2. Änderung | 686b859e- 5340-c388- 6009- d13194cc86dc | VG Daun | Bodennutzung (3.4), Bewirtschaftungsgebiete/Schutzgebiete/geregelte Gebiete und Berichterstattungseinheiten (3.11) |
| | | 824f8db2- 8201-5049- 12c0- bd17cc9f04bc | VG Kirchberg | Bodennutzung (3.4), Bewirtschaftungsgebiete/Schutzgebiete/geregelte Gebiete und Berichterstattungseinheiten (3.11) |
| | | f0865a89- 161a-6db3- c3bb- 1ccdcec519da | VG Diez | Bodennutzung (3.4), Bewirtschaftungsgebiete/Schutzgebiete/geregelte Gebiete und Berichterstattungseinheiten (3.11) |
| | | e4066867- 4b09-4b0a- 3ba6- 15060baeb270 | VG Gerolstein | Bodennutzung (3.4), Bewirtschaftungsgebiete/Schutzgebiete/geregelte Gebiete und Berichterstattungseinheiten (3.11) |
| | | 9b0530e8- 0f38-a937- f8a5- f0e21057780d | VG Daun | Bodennutzung (3.4), Bewirtschaftungsgebiete/Schutzgebiete/geregelte Gebiete und Berichterstattungseinheiten (3.11) |
| | | 6111447e- 97cb-2862- 6048- de6a020dac1c | VG Daun | Bodennutzung (3.4), Bewirtschaftungsgebiete/Schutzgebiete/geregelte Gebiete und Berichterstattungseinheiten (3.11) |
| | Vorranggebiet für Hochwasserschutz | 12755418- 1b2a-c805- 2db3- c90c0ee3fd2f | SGD-Nord - AG GIS | Bodennutzung (3.4) |
| | | b1e6a74f-0c6f- b534-6111- 936b43626d5a | VG Hamm | Bodennutzung (3.4), Bewirtschaftungsgebiete/Schutzgebiete/geregelte Gebiete und Berichterstattungseinheiten (3.11) |
| | | 3ed7b34f-6b5f- 351f-fc3e- a549358a5aa8 | VG Römerberg-Dudenhofen | Bodennutzung (3.4), Bewirtschaftungsgebiete/Schutzgebiete/geregelte Gebiete und Berichterstattungseinheiten (3.11), Flurstücke/Grundstücke (Katasterparzellen) (1.6) |
| | | b49f93c8-34f5- | | Bodennutzung |

Figure 34: INSPIRE Catalog of Rhineland-Palatinate [Screenshot]

Concluding one can say RP has a leading position in Europe because of the concept of using an INSPIRE-proxy. However this approach is very special and fitted to the conditions of RP. Indeed the system was adopted of several other institutions and Saarland³³ and Hesse already joined RP, but it is not portable to NRW. A completely different approach is taken by NRW, far away from a central proxy. Although the regional authorities provide support, but they don't take over all the work from the district administrations and communities. An area-wide homogeneous SDI as basis is simply missing.

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http://geoportal.saarland.de/mapbender//php/mod_inspireDownloadFeed.php?id=e20302b0-0338-449e-9c0e-11378779a129&type=SERVICE&generateFrom=wfs&wfsid=243

5.2.2 Lower Saxony

Similar to Mapbender in Rhineland-Palatinate Lower Saxony also developed an open source solution for providing INSPIRE Download Services, the ATOMFeedGenerator. In contrast to Mapbender it is not dynamic, after generation the feeds are stored in a file system, accessible with help of OpenSearch requests (see chapter 5.1.1). The ATOM-Feeds are available in the common metadata catalogs³⁴ and in a separate section of the geoportal, which shows the outer appearance of the ATOMFeedGenerator web application³⁵ (see Figure 35).



Figure 35: Start page of MDI-DE with separate INSPIRE section [Screenshot]

The software was developed in context of the project MDI-DE (Marine Daten-Infrastruktur Deutschland) [MDI-DE PROJECT]. The MDI-DE is a cooperation of 11 public authorities at the coastline of Germany. Goal is the building of a joint geoportal for exchanging and publishing data and information. Thereby the INSPIRE specifications should be achieved by using metadata and network services [MDI-DE PROJECT2]. Interesting aspect here is the methodology of the workflow. An absolute new software was developed in order to comply with the INSPIRE requirements. This software tool is free (open source) and is continually further developed. This is only possible, if necessary manpower and know-how is available and gets realized in a

³⁴ <http://nokis.niedersachsen.de/NOKIS/servants/~Render?recordId=ed28c06a-adb8-4178-bb52-471043bba7cc&format=fullhtml&download=false&locale=de&backView=browse>

³⁵ <http://mdi.niedersachsen.de/atomFeed/>

working project. It is a good example of how to approach the INSPIRE requirements and implement useful solutions.

As already mentioned the software is fitted to the catalogs NOKIS and NUMIS and at the moment not applicable in NRW. A usage in NRW is imaginable, but this would require further modification of the source code.

5.2.3 Other Countries

Other members of the European Union of course also work on the implementation of INSPIRE. In case of INSPIRE Download Services are pre-defined ATOM-Feeds a popular solution due to the simplicity compared to direct-access WFS. But the countries have different approaches and use other software solutions. Another aspect is the language, all the software tools mentioned above support German language. This is a major factor in working with ATOM-Feeds because metadata is always provided in the native language. Summarized the foreign solutions are not relevant for NRW. Anyway here are the links to two concepts, Netherlands and Great Britain, for the sake of completeness.

Netherlands:

http://wiki.geonovum.nl/index.php?title=Aan_de_slag_met_INSPIRE

United Kingdom:

http://data.gov.uk/location/guidance_and_tools

The actuality and importance of ATOM-Feeds for the implementation of INSPIRE Download Services is demonstrated in the following list. It contains exemplary feeds of several EU member states.

Austria

<http://gis.stmk.gv.at/inspire/downloadservice/DownloadServiceFeed.xml>

Denmark

http://schemas.kms.dk/kf_dwl/inspire/feed/RoadLink.xml

France

<http://geoservices.brgm.fr/geol1M/fr/download/capabilities.xml>

Ireland

https://www.geoportal.ie/geoportal/download/ProtectedSites_NHA/npws-inspire-protected-sites-natural-heritage-areas.atom.en.xml

Netherlands

<http://services.rce.geovoorziening.nl/www/download/nl.xml>

Poland

http://geo.stat.gov.pl/atom_web-0.1.0/atom/PD

Scotland

https://gateway.snh.gov.uk/natural-spaces/inspire_download.atom.xml

Spain

<http://www.ign.es/atom/ds.es.xml>

Sweden

<http://gis-services.metria.se/msbfeed/vma.xml>

6 Realization Alternatives

Based on requirements and introduced software solution at this point potential realization alternatives will be discussed. This is done by an analytic consideration and evaluation of different approaches and workflows. The result will not be a final concept but a proposal for the best proceeding.

Shortly summarized the task is finding a solution for the implementation of INSPIRE Download Services with ATOM-Feeds in NRW. Following aspects and problems must be considered during the research (see chapter 4.4):

- Presenting location for ATOM-Feeds
- Dynamic generation vs. static storage
- Basis of generation
- User-friendliness
- Integration of the tool into GEOportal.NRW
- Open source
- Effort

All the use cases except of 6.3 deal with the approach of generating ATOM-Feeds based on existing metadata. The contrary approach is also imaginable, that means first generate the feeds and then derive metadata from the ATOM-Feeds. However this method is not practicable and therefore not in use yet. Reason is the existence of metadata catalogs with many registered metadata. So it is useful to use this existing data in order to generate ATOM-Feeds based on metadata. Therefore the other approach will not be considered further. In the following 5 realization alternatives will be introduced.

6.1 Generation directly in GEOkatalog.NRW during metadata registration

First potential workflow is the direct generation of ATOM-Feeds based on registered metadata. That means a data provider has the chance to publish an ATOM-Feed when inserting metadata for a dataset. This could be done by an additional attribute 'Generate ATOM-Feed Download Service' within the metadata editor. That requires not just a validator for checking the attributes filled in but also scripts are necessary for creating the ATOM-Feeds. This could be JavaScript or PHP scripts similar to the Mapbender solution in RP. The difference is that the Feeds in this case must be static

and not dynamically generated. A question that arises here is where to publish the services. As already mentioned GEOportal.NRW is no database, but IT-NRW and Geobasis NRW own webserver for WMS and WFS services. A solution could be making available this web space for the use of ATOM-Feeds.

Precondition of the described scenario is the registration of correct and complete metadata by the data provider. This must be validated with an extension within the registration tool smart-editor. This is similar to the registration of metadata. A publication is only possible after the validation. However that means an integration of additional features would be necessary in order to provide this method.

A concrete use case for this realization alternative could be as follows:

- A data provider has a INSPIRE relevant dataset (e.g. land-use plan in zip format). The zip-file is already online available via simple download-link.
- The provider wants to publish the data in compliance with the regulations on INSPIRE Download Services.
- He goes to the GEOkatalog.NRW website, activates the option 'Generate ATOM-Feed Download Service' and registers the metadata for the dataset with help of the smart.editor.'
- At this point the work for the provider is finished. The rest of the workload is done automatically by the software solutions.
- After validation of the metadata entries a script generates Service-Metadatas, Service-Feed, Dataset-Feed and OpenSearch Description Document based on the registered metadata. All these XML documents are connected with each other.
- The Service-Metadatas are registered to the GEOkatalog.NRW, the other documents are published on a webserver of IT.NRW. The pre-defined INSPIRE Download Service is complete.
- When a customer wants to access the data, he searches in the GEOkatalog, gets the Feeds from IT.NRW server and will be forwarded to the final download from the server of the data provider. See the Publish-Find-Bind principle in chapter 2.1.3.

Following additional elements based on the existing architecture are needed for this solution:

- Customization of the existing validator
- Adding of new scripts and functionalities for generating ATOM-Feeds, Service-Metadata and OpenSearch documents
- Providing a webserver with OpenSearch implementation for the publication of required documents

6.2 Generation of ATOM-Feeds with extern software solution

Another potential use case is the generation with help of external software solutions. In contrast to alternative 6.1 no customization of the existing system would be necessary. The tool must be able to execute following steps:

- Pull metadata (Service-Metadata) from the catalog over the CSW interface
- Read the required attributes from the XML documents
- Generate Service-Feed, Dataset-Feed and OpenSearch Description Document based on the received attributes
- Publish the documents as a INSPIRE Download Service

Precondition for this solution is the existence of conformant Service-Metadata. Based on complete metadata external tools can easily extract the required information and generate ATOM-Feeds. Two potential solutions for this use case are ATOMFeedGenerator and FME. The ATOMFeedGenerator is a very good overall solution, including the whole transformation process and the publishing with an own ATOM-Client. Only disadvantages of this open source tool are the non-applicability for the GEOkatalog.NRW and the absence of a user interface. FME whereas is very user friendly by providing an intuitive workspace. Similar to the other tool FME is also imaginable as overall solution, but needs further development at this stage. The workspace for ATOM-Feeds are still in development and not yet published. See Table 7 for pros and cons of both solutions.

Table 7: Comparison of ATOMFeedGenerator and FME

| | ATOMFeedGenerator | FME |
|------------|--|---|
| Pro | <ul style="list-style-type: none"> • Software is completed • Overall solution, including generation and publication with OpenSearch • Open source | <ul style="list-style-type: none"> • Overall solution imaginable, but not yet implemented • User friendly • Easy extension with FME Server or ArcGIS for INSPIRE |
| Con | <ul style="list-style-type: none"> • Does not work for GEOkatalog.NRW, needs customization • No user interface | <ul style="list-style-type: none"> • Workspaces for ATOM-Feeds are not finalized yet, still in development • Software is not free |

For starting the generation process the user has just to type in the IDs of the relevant Service-Metadata and the link to the CSW interface. Right now there is no possibility to automatically identify relevant datasets in a catalog. Therefore this must be done by hand. This proposed solution is well realizable in NRW, on condition that the software is customized for the requirements in NRW.

6.3 Overall Solution with Mapbender

The third realization alternative is an overall solution with Mapbender, which is a very interesting approach. The solution is based on the concept of Rhineland-Palatinate, which uses Mapbender as a central proxy for INSPIRE. Main aspect is the centrality, everything is administrated at one place: datasets, metadata, services. All manpower and know-how was aggregated for finding an overall solution. This takes over a lot of works from the communes in RP and therefore minimizes the potential errors. The special thing of this solution is the dynamic generation of INSPIRE Network Services. Download Services as well as Discovery Services are created during runtime. For this implementation an INSPIRE-proxy is necessary in order to handle the requests for Download Services. That is done by PHP scripts with help of Mapbender.

So the keywords for this Mapbender approach are centrality, dynamic and INSPIRE-proxy. This differs significantly from the approach in NRW. Neither the dynamic aspect nor the centrality were even considered. Quite apart from the different software architecture. Implementing this realization alternative in NRW would mean an adoption of the whole system with Mapbender, INSPIRE-proxy and centralized

implementation. That means all previous solutions should be rejected, no matter how much time and effort was needed to implement them. Therefore this approach is not applicable in NRW, even if the solution works very well in RP. It is a better idea to keep on the existing system in NRW and develop a solution for ATOM-Feeds on top of it.

6.4 Overall solution with FME and FME Server

Instead of using FME as a single tool in a workflow as described in 6.2 it is also imaginable to cover the whole workflow with help of FME Server: reading metadata, creating ATOM-Feeds, publishing Download Services. This procedure could be provided as a web application based on FME Server³⁶ That would be usable by all potential data providers over a web-based user interface. Users could have following options:

- Upload of a dataset together with corresponding metadata document (Service-Metadata) at the FME Server application user interface
- Upload of a dataset on own webserver of data provider, registration of Service-Metadata in the GEOkatalog. Committing both links (CSW-request for metadata, download-link for dataset) to the application

That is everything that a potential data provider has to do. From this point FME Server takes over the work with the usual steps: reading metadata, creating ATOM-Feeds, publishing Download-Service. For realizing this workflow a webserver must be provided. On the one hand for FME Server application and on the other hand for the generated ATOM-Feed. Furthermore there must be an OpenSearch implementation on the server in order to provide the required INSPIRE operations. In the first use case the datasets are stored on the central webserver. The metadata is registered automatically in the GEOkatalog. It has to be discussed if this central storage is conformant with the requirements of NRW. In the second use case only the feeds and the OpenSearch document are stored on the server. Both use cases expect existing metadata. That means at any rate the data provider has to provide metadata as well.

³⁶ For exemplary implementations of FME Server see:
<http://playground.fmeserver.com/demos/>

Benefit of this realization alternative is the user-friendliness. Most of the workflow is automated, the complexity remains hidden from the user. Summarized following elements are required:

- FME Server
- FME workspaces for ATOM-Feeds (INSPIRE Solution Pack)
- Central webserver for application, OpenSearch implementation and storage possibilities for ATOM-Feeds

In total this is a very imaginable solution for NRW. However these are just theoretical ideas, not yet implemented.

6.5 Packaging

An interesting use case for ATOM-Feeds is the packaging („Konfektionierung“) of existing WMS and WFS services. Most of the registered services in the GEOkatalog are implemented with the ‘old’ OGC standards WMS 1.1.1/1.1.0 and WFS 1.1.0. But the specification for INSPIRE Network Services define WMS 1.3.0 and WFS 2.0 as the required standard. These have extended functionalities are therefore they are not easy to implement. The idea is to ‘pack’ the old services into a façade of ATOM-Feed and so to provide INSPIRE conformant pre-defined dataset Download Services.

Up to now this solution was not considered in NRW. However this is an interesting approach, a closer look will maybe worth it. Many provider of WMS and WFS will not be able to easily switch into the new format, due to the necessity of the latest software solutions (e.g. ArcGIS for INSPIRE). At this point providing ATOM-Feeds could be a good solution due to the reduced complexity.

The same questions rise as in the previous suggested alternatives. What software tool for generating ATOM-Feeds? Dynamic or static? Central or decentral? Rhineland-Palatinate solved this problems with a dynamic implementation based on Mapbender. However the existing PHP scripts are not easily portable to NRW. So for an implementation of this additional ATOM-Feed use case first a clarification of fundamental questions mentioned above is necessary. Thereafter complex implementations are to be made.

7 Discussion of Results

After defining and inspecting the selected realization alternatives it is necessary to evaluate the pros and cons of each solution in order to give a proposal for the best strategy in NRW. The discussion is the result of the whole workflow of specifying requirements, identifying software solutions and defining realization alternatives. Evaluation criteria are listed in chapter 4.4. Table 8 summarizes the pros and cons of the realization alternatives.

Table 8: Comparison of realization alternatives

| | Pro | Con |
|---------------------------------------|---|---|
| 1. internal generation | <ul style="list-style-type: none"> • User friendly, easy to handle for data providers • Whole lifecycle covered in one step | <ul style="list-style-type: none"> • Customization of GEOkatalog necessary • Development of scripts needed |
| 2. external generation | <ul style="list-style-type: none"> • Easier to implement than alternative 1 • No changes in GEOkatalog necessary | <ul style="list-style-type: none"> • Conformant Service-Metadata necessary • Customization of the tool required |
| 3. central Mapbender | <ul style="list-style-type: none"> • Well-working overall solution • Services always up-to-date due to the dynamic generation | <ul style="list-style-type: none"> • Not realizable in NRW because of the centralized approach and the Mapbender basis |
| 4. FME Server | <ul style="list-style-type: none"> • User-friendly • Whole lifecycle covered in one step | <ul style="list-style-type: none"> • Solution not existent yet, must be developed • Software must be acquired |

Alternative 1, 2 and 4 are theoretically realizable in NRW. Solution 3 is not useful for this use case, even if it is a very good implementation of INSPIRE. Alternative 6.5, the packaging, is also very interesting but unexplored. FME and FME Server could be a solution for this problem, but connected with lot of development work. At this

point it is questionable, whether providing WFS 2.0 and WMS 1.3 would not be easier than implementing the approach of packaging.

Generally speaking, FME is a good solution for the generation of ATOM-Feed. On the one hand the software is very user friendly easily customizable, that are important criteria for the data provider. On the other hand it harmonizes very well with the whole lifecycle of providing Download Services for INSPIRE. That means a data provider can go all the way with one software. This includes especially the data transformation into the INSPIRE data model with help of the INSPIRE Solution Pack. In total alternative 2 is the most appropriate method for NRW from view of the software provider. For data providers solution 1 and 4 may be better because of the usability.

Summarized the regional authorities have two options in order to support data provider in publishing ATOM-Feeds:

1. Engage an external service provider in order to implement alternative 2 or 4 (FME, FME Server or ATOMFeedGenerator)
2. Use own capabilities (e.g. IT.NRW) for developing an extension for alternative 1 or customizing the software for alternative 2

8 Conclusion

The topic of ATOM-Feeds was examined from different perspectives during this thesis. From the data provider point of view, from the users point of view and from an overall technological view. The goal of this conceptual work was the development of an implementation strategy for INSPIRE Download Services in NRW. In general that was done in 3 steps. In the beginning there was the requirement analysis, dealing with common technical requirements as well as the current state in NRW. Results are a set of criteria for the final evaluation based on the requirements of NRW. The second step was characterized by the testing and classification of existing software solutions, which led to a list of software alternatives. In the final step several realization alternatives were developed and introduced based on the identified requirements and software solutions. The main focus was always directed to the two research questions defined at the beginning of the work:

- What implementing alternatives for automatic generation of ATOM-Feeds based on ISO metadata exist?
- How do the identified solutions suit in order to fulfil the requirements of NRW?

The research showed that a series of software solutions for ATOM exists. But they are applicable just to a limited degree. Most of the tools are not directly usable within the existing structure of NRW. The tools are either developed for a very special infrastructure (ATOMFeedGenerator, Mapbender) or simply not yet finalized (FME INSPIRE Solution Pack). That means at this point the implementation is not completed, but with help of this thesis the foundation is laid.

It also showed the difficulty of directly taking advantage of ATOM-Feeds. Due to the specific structure this INSPIRE Download Services most of the existing software tools have problems to analyze the underlying datasets. Another finding is the discrepancy of INSIPRE implementations of the different federal states in Germany. Even if INSPIRE makes the same demands to all members, every authority uses an own approach. On the one hand the current state of implementation differs greatly in many cases. Some stakeholders already completed the implementation and provide are-wide interoperable Network Services. Other stakeholders are still at the very beginning. On the other hand the used concepts and approaches are very diverse. The range of software tools covers professional tools as well as self-development open source solutions.

Summarized there is no perfect solution for a best-practice implementation. Every data provider has a different architecture with unique requirements. All of them need an own concept for the INSPIRE implementation. This thesis tries to support the implementation of the specific solution in NRW. Due to the INSPIRE time plan for providing Network Services there is still a lot of time left until the final implementation. However, data providers should not wait too long with the implementation, because this thesis demonstrated the broadness and complexity of the topic INSPIRE.

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