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Organizational Framework

Data maintenance and geo-processing enabling the ELF data interoperability at cross-border level.

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Ref.	Title/Version/Publication Date/Author
[1]	Jakobsson, Antti. <i>European Location Framework White Paper v1.0.</i> 29 Feb 2012.
[2]	EU. <i>COMMISSION REGULATION (EU) No 1089/2010 of 23 November 2010 implementing Directive 2007/2/EC of the European Parliament and of the Council as regards interoperability of spatial data sets and services.</i> s.l.: Official Journal of the European Union, 8.12.2010. p. L 323/11. from http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L:2010:323:FULL&from=EN
[3]	Portele, C. <i>Methodology & Guidelines on Use Cases & Schema Development.</i> s.l.: from http://www.eu-rise.org , 2007
[4]	UN-GGIM: Europe Coordination Group,. <i>Working Group 1 - Data Definition and Access Conditions Report.</i> Consolidated Version 10 April 2014. http://un-ggim-europe.org/sites/default/files/GGIM-Europe-Working%20Group%201%20-%20Report%20-%2020140411.pdf
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I Scope

The document describes the principles for obtaining cross-border data interoperability in different matters: semantic, organisational and technical.

Based on best practice examples in pan-European production and on test cases of the ELF project, the deliverable provides recommendations for achieving semantic and cross-border interoperability of geospatial data and provides some findings and conclusions on the ability to reach this cross-border level for the ELF data.

The document describes the organisational processes for updating and maintaining the ELF data and the dependent data specifications in case the ELF data will be extended according to users' needs and applications.

In matters of technical interoperability, the document describes an ELF data workflow starting from national data sources to their publication in web services and includes the proper use of the geo-processing tools in quality, edge-matching, change detection and generalization. This process is named the data supply chain. Moreover, the documents analyses the feasibility of applying the INSPIRE data interoperability principles on the ELF data and their implication on the geo-processing tools, data supply chain, web map application and data publication on Web services.

The deliverable is a living document and might be amended by the end of the project according to experiences, findings and conclusions taken from use cases.

2 Interoperability Levels in the ELF Framework

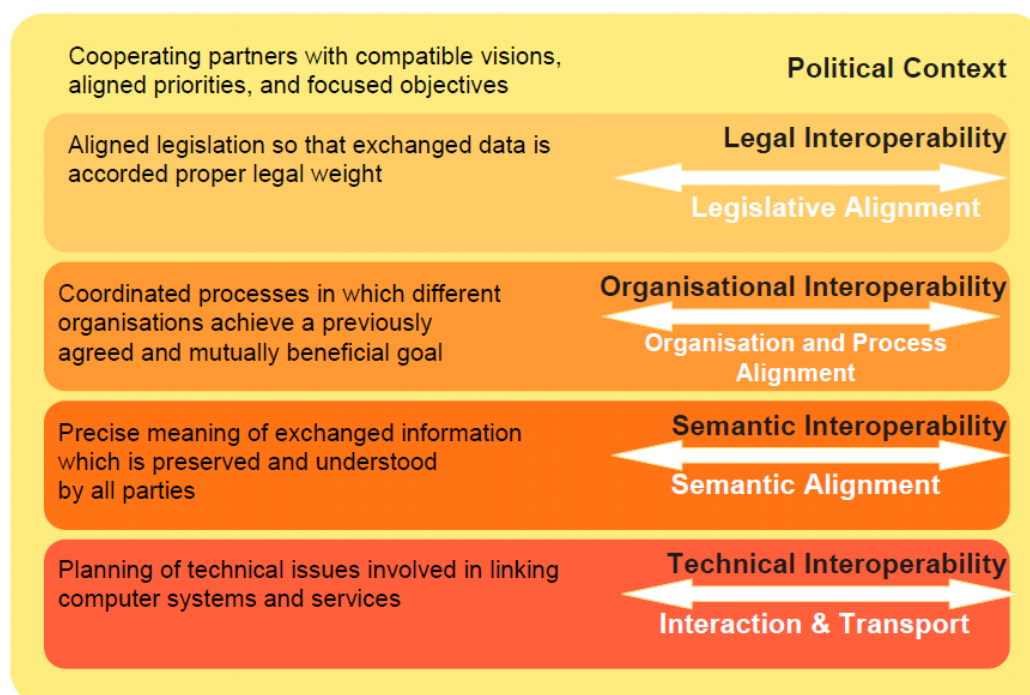
The interoperability considered in the ELF Framework is related to legal, organizational, semantic and technical levels [1].

At a legal level these agreements are rendered specific and binding via legislation, including European directives and their transposition into national legislation, or bilateral and multilateral agreements, which are outside the scope of the ELF.

At an organisational level, interoperability agreements can, for example, take the form of MoUs or SLAs that specify the obligations of each party participating in cross-border business processes.

At the semantic level, interoperability agreements can take the form of reference taxonomies, schemes, code lists, data dictionaries, sector based libraries and so forth.

At a technical level, interoperability agreements include interface specifications, communication protocols, messaging specifications, data formats, security specifications or dynamic registration and service discovery specifications [1].



This deliverable will focus more specifically on the organizational, semantic and technical level.

3 Semantic Interoperability

One objective of the ELF project is to ensure that the national datasets, available and accessible on the ELF platform will comply with INSPIRE and moreover provide cross-border consistency and a 'certain' degree of data interoperability that will allow their use in a broad European perspective. It is therefore important to determine which requirements in the matter of data interoperability which must be reached to allow their specific use in a pan-European framework. These requirements may vary by theme and level of detail depending on the use.

3.1 Degrees of interoperability

In a way, we could define a graduated scale evaluating the degree of interoperability of spatial datasets (see Figure 1).

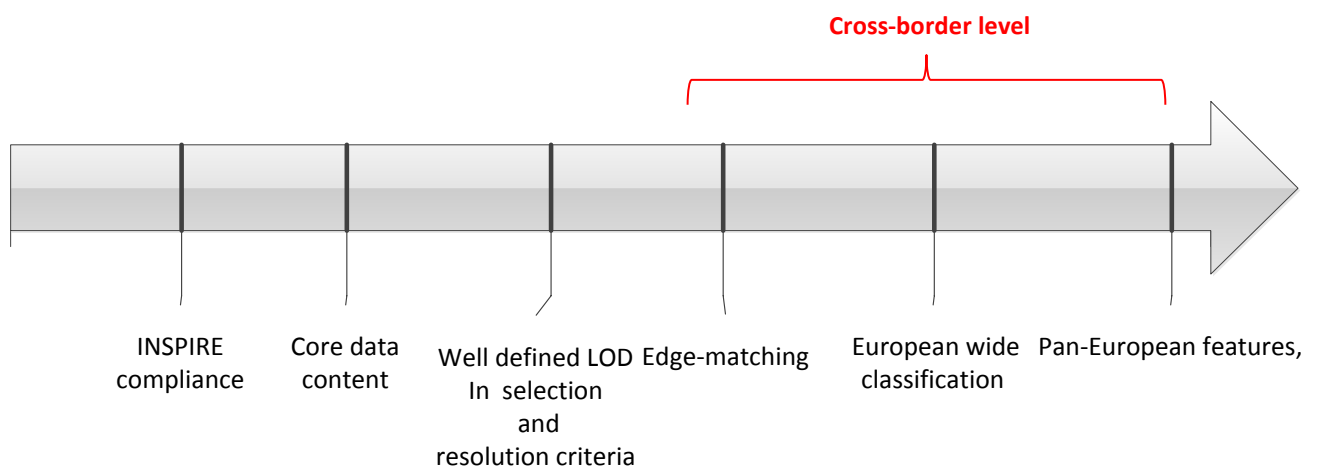


Figure 1: Degrees of interoperability of the ELF spatial datasets

This graduated scale shows the degrees of interoperability in such a way that the previous degree must be achieved in order to be able to reach the following one. This graduated scale indicates a step by step approach to achieve the highest degree of interoperability including for pan-European features.

The process of data harmonisation means, as a whole, progressing and achieving the different degrees of interoperability.

3.1.1 INSPIRE compliance

“INSPIRE compliance” of ELF spatial datasets data is the basic step and has been defined as the general objective for ELF.

INSPIRE regulates the provision of existing environmentally relevant geospatial data from NSDIs in a consistent way. The regulation ¹, as regards interoperability of spatial datasets and services, provides “the common data types, the identification of spatial objects, metadata for interoperability, generic network model and other concepts and rules that apply to all spatial data themes” and “where practicable, harmonisation of spatial data sets and spatial data services” [2].

In other words, the INSPIRE interoperability sets up the technical framework, laying the foundations for “interoperability, in a service-based architecture rather than (full) harmonisation of the underlying data models.” [3]

“The contribution of INSPIRE is to provide the European frame for sharing interoperable data across domains through services, including statistical data referenced with geospatial data. INSPIRE sets standards and obligations, to share and provide existing data but it does not create an obligation to update existing data nor to produce new data. Consequently some countries do not supply data for several INSPIRE themes, resulting in holes in the needed pan-European datasets; currently core datasets do not exist at European level. Data gaps and out-datedness will not be solved by INSPIRE. Even data harmonisation will not be fully solved. **INSPIRE will not result in pan-European specific and minimal core datasets, which is not in its scope.**” [4]

INSPIRE compliance means mainly that data will be provided in a common data model and common coordinate reference system(s). However, as most of INSPIRE concepts are “voidable (i.e. having to be provided if available or derivable at reasonable cost), INSPIRE data sets may still remain quite heterogeneous regarding their semantic content (how many features and attributes are populated) and their geometric content or level of detail.

3.1.2 Core data content

The UN-GGIM: Europe Coordination Group has produced a report [4] targeting the core Geospatial Reference Data (cGRD) at European level, covering; the definition, the production, the funding and the licensing. It proposes to “define core Geospatial Reference Data (cGRD) through minimum topics and attributes regarding the Global and European requirements and the possibility from all Member States (MS)”.

The UN-GGIM: Europe report doesn’t really define a cGRD but possible processes of cGRD definition, which should meet the following conditions:

- cGRD should satisfy from bottom (MS) to European and Global needs including cross-border and sea-land interface needs.

¹ Commission Regulation (EU) N° 1089/2010 implementing Directive 2007/2/EC of the European Parliament and of the Council as regards interoperability of spatial data sets and services.

- cGRD should provide a skeleton for all geospatial information (GI), providing an unambiguous location for any user's information, and a geographic context to allow others to better understand the spatial phenomena.
- cGRD should have similar and comparable resolution for geospatial reference in all MS and made seamlessly assemblable.
- Based on these cGRD every MS and other public institutions could complete the entire GRD regarding to their own needs.
- cGRD should facilitate the harmonization and integration of the rest of GI i.e. the merging of GI from various sources.
- Same input cGRD is needed from all MS for inter-comparability and analysis.
- cGRD should help reducing GRD production costs by increasing GRD mutualisation.

UN-GGIM: Europe continues to work on these issues (see <http://un-ggim-europe.org/content/wg-a-core-data>).

This concept of core data content, in a broad European and Global framework, is out of scope of the ELF project.

The project ELF defines the core data content in a more restrictive manner. The 'core' part of a data is defined by the minimum data content required by most or at least by basic applications, and user requirements, and whose data collection and maintenance is considered as feasible and achievable at reasonable costs. Typically, this might be the mandatory feature types and attributes that will be produced and made available in all countries in order to avoid gaps in the European coverage

Core data content may be defined independently from any Level of Detail (LoD) implying that, ideally, the data should be collected once at the most detailed level.

The establishment of a core data content and the determination of what should be mandatory and available in a European coverage is not a one-shot concept but is usually driven in a step by step approach based on compromise on what the data producers can collect and maintain at affordable costs and meet the main identified users' requirements and applications.

What might be done during ELF project is to define 'core' content based on a balance between:

- The data widely available among data producers (from matching tables).
- The user requirements, already well identified as e.g. the mandatory concepts of EBM/ERM/EGM.
- The data required for services and applications like Base Map and GeoLocator, and data required by most of ELF WP7 applications.

The ELF data specifications are developed as a set of profiles of the INSPIRE data specifications comprising the parts of INSPIRE data specifications that are in the remit of the NMCAs and other national authorities and for which a cross-border coverage is of interest. The analysis of the ELF matching tables revealed the matching concepts between INSPIRE and NMCA data holdings. This results in the common part of ELF/INSPIRE. Additional content included in ELF, with respect to INSPIRE, is coming from a user requirements survey and/or from specifications of existing data with respect to data definitions and classification of features, data quality requirements, multilingual aspects, and data representation.

Additionally, ELF might then put some mandatory quality rules for the population of these “core” concepts and define conformance classes for data compliance with these quality rules in order to encourage NMCAs to better populate their INSPIRE data sets².

3.1.3 Well defined LoD in selection and resolution criteria

A core data content may be portrayed or represented at different LoDs and therefore be available by means of several spatial datasets.

INSPIRE defines the level of detail (LoD) as the quantity of information that portrays the real world which can be described by the following parameters [5]:

- the type of information (the spatial object type and its properties),
- the selection rules (explaining which entities of the real world are represented in the dataset),
- the accuracy of the attributes,
- the semantic granularity (e.g. the LoDs in candidate OGC standard CityGML),
- the type of geometries (3D, 2.5D, or 2D; volume, surface, curve or point),
- the accuracy of the geometries.

Those parameters are usually a matter of a wide range of definitions for a declared LoD according to their specific use or applications, i.e. for spatial analysis or for mapping purpose. Up to now, there are no standard criteria for defining a specific scale (or LoD), each data producer having its own criteria.

ELF has classified the spatial datasets according to several LoDs:

LoD	Scale range	Thematic scope
Master Level 0	Larger than 5k	Cadastral Parcels, Buildings, Addresses
Master Level 1	5k – < 25k	ELF Topo (Admin Units, Hydro, Transport, Elevation, GeoNames, etc.)
Master Level 2	25k – < 100k	ELF Topo generalised (1:50K)
Regional	100k – 500k	ELF Regional themes
Global	> 500k	ELF Global themes

However, the ELF datasets originated from national datasets, and declared at a same LoD, might still result in discrepancies that will make the usage of the data at cross-border level difficult.

ELF has taken different approaches for detailing and defining suitable selection rules, type of geometry and accuracy.

² See D2.3.6 Quality
E.L.F. Deliverable D2.3.1

Regarding Master Level 0 and 1, the ELF approach has been to prioritize the existing most detailed LoDs of NMCA's without trying any harmonization between national criteria.

At Master Level 2, the ELF approach has been to set up common resolution and selection criteria based on what are the most commonly applied criteria among NMCA's. However the approach is not so obvious when looking to the discrepancies of the national thresholds declared for the same LoD.

By way of example the following table gives the national thresholds for “standing water”:

Country	keep if area greater than:
Belgium	>1.500m ² , Internal width must be >= 20m (enlarged when necessary)
Czech Republic	>=2.500m ² or aggregated from several smaller objects
Germany	>5.000m ²
France	Scan Express: all lakes/ponds whose length > 20 m all watercourse whose width > 7,5 m all artificial basins whose length > 10 m BD Carto: area > 200.000m ²
The Netherlands	> 1.000m ² ; Amalgamate areas < 1000m ² with other water or terrain
Sweden	>500 m ² ; No points

Regarding the selection rule “keep if area is greater than”, the big discrepancies don’t allow selecting a unique value but rather a range of values that are the “most commonly” applied.

At Regional and Global level, the ELF approach has been to keep the rules applied for EuroGeographics products: EuroBoundaryMap (1:100k), EuroRegionalMap (1:250k) and EuroGlobalMap (1:1000k) and EuroDEM, whose resolution and selection criteria have already been well defined.

Finally, setting up common rules based on national criteria is not enough to achieve the level of harmonisation that is suitable for cross-border application. Here is the approach that has been taken for setting the selection of watercourses of the EuroRegionalMap product (ERM) at a scale resolution 1:250k:

The ERM data specifications (EuroGeographics, EuroRegionalMap = Specification and Data Catalogue, 4.6 user version 30/06/13) specify the resolution of 1:250k primarily set up generic selection criteria allowing the use of national criteria as follow:

- EuroRegionalMap data are collected at a level of detail that approximates the medium scale product range (from 1:200k to 1:300k). Portrayal criteria mentioned in the data dictionary remain at a generic level and it is up to producers to set up and detail its own selection criteria.
- The appropriate scale for hard-copy output should be at 1:250k. Geometric data resolution in the density of vertices on an edge should be as low as possible keeping a realistic size and

shape of the feature. The horizontal geometric resolution should be stored to the equivalent precision of 5 meters or 0.2 in arc-seconds or 0.00005 in decimal degrees.

Selection and portrayal criteria for watercourses are the following:

- Watercourse as area: Watercourses that form up a logical water network with width ≥ 125 m.
- Watercourse as line: Watercourses that form up a logical water network with width < 125 m.

Applying this generic rule, which allows the use of national criteria, has revealed discrepancies that were not allowing proper usage at European level.

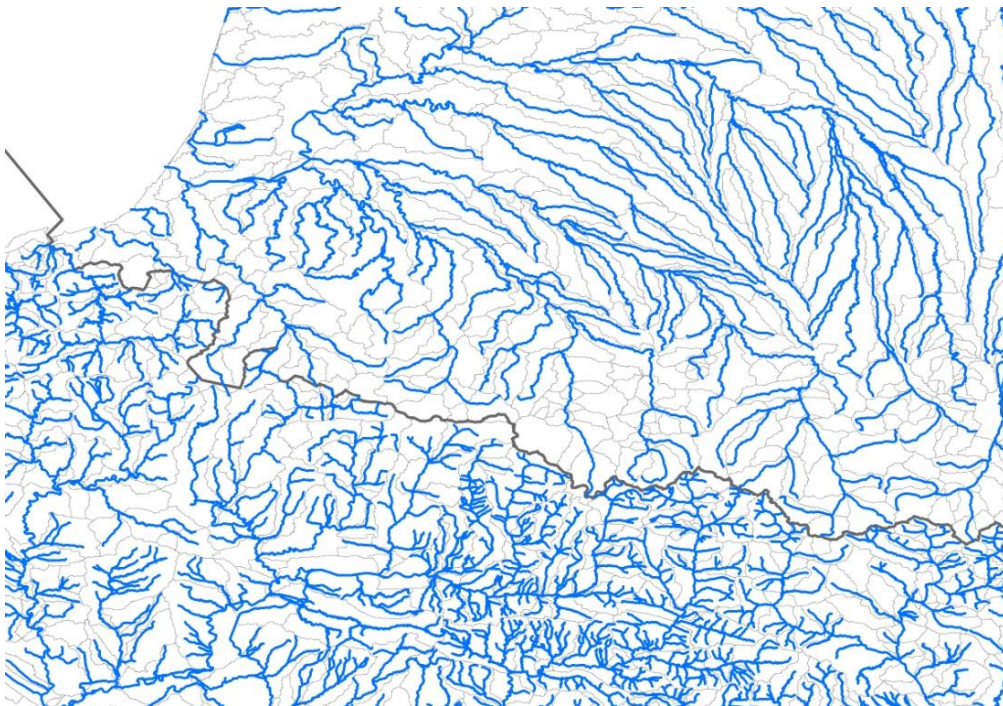


Figure 2: Hydrographical network (Spain-France) with national selection criteria

However, it was difficult at that time to decide which national criteria were able to meet European criteria. As reference for deciding on a common European selection criteria an already existing pan-European spatial dataset produced at the European Environment Agency, named ECRINS, has been used. This dataset contains the elementary drainage basins ($10 \text{ km}^2 - 100 \text{ km}^2$) for a scale resolution of 1:100 000 which were used to achieve the consistency of the watercourse network across borders (see Figure 3).

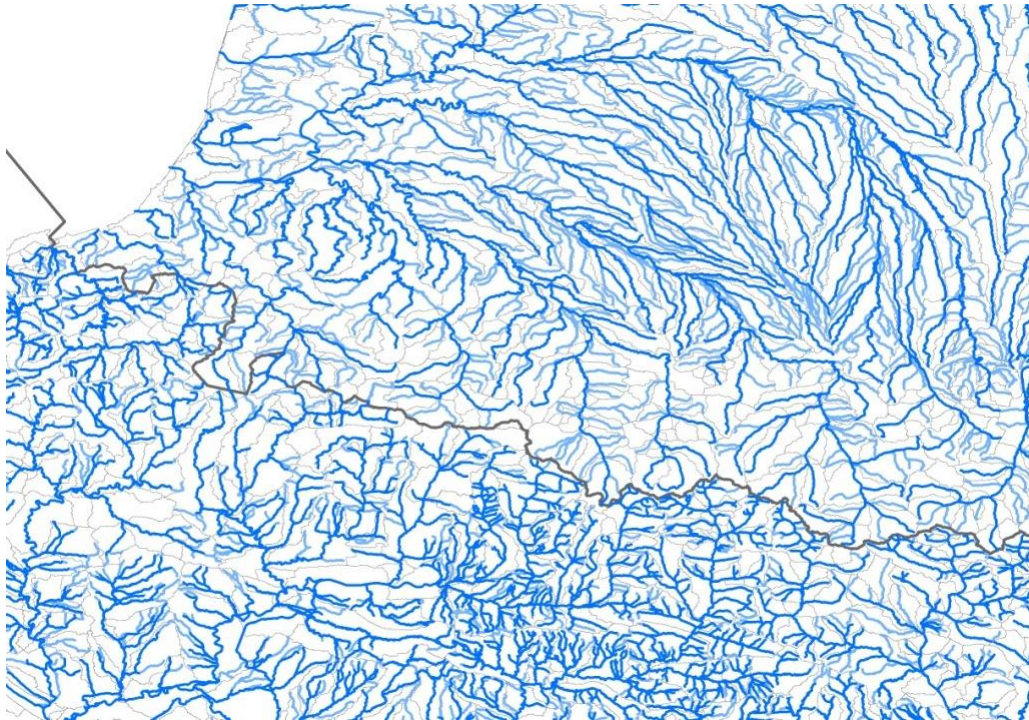


Figure 3: Hydrographical network (Spain-France) with European selection criteria

Light blue – added river segments

3.1.4 Cross-border level

This level implies that the data are consistent across-borders and properly edge matched on a boundary alignment like the international boundary.

The INSPIRE Directive Art 10 [2] expresses the need for cross-border consistency between member states; however no technical guidance has been provided in that matter.

ELF defines three sub-levels for achieving the cross-border interoperability: the edge-matching process, the application of a European wide classification and the pan-European features.

The edge-matching process

The edge-matching concept consists of matching the features in their geometry and semantically between neighbouring countries and using as delineation the ELF International Boundaries (ELF IB). The concept is to set up connecting features (CFs) located on the ELF IB that will serve as anchor points for the matching processing. The advantages of the connecting features are:

- Previously fixed edge-matching cases can be retained,
- It's not necessary to have related data from neighbouring countries to process them to edge-matching,
- It prevents any discrepancies in an update cycle and availability of neighbouring datasets.

The ELF project will provide technical guidance on how to proceed and maintain edge-matching through data updates (D2.3.3 Edge-matching) and tools to edge-match the spatial datasets at international boundaries (D4.4 Edge-matching tools). However some prerequisites are needed to do it properly; the spatial datasets must share the same data content and similar resolution criteria; the edge-matching process must use agreed boundaries that will serve as the delineation between neighbouring datasets. The agreed international boundaries are collected into a European reference dataset (ELF IB) and made available on the ELF platform at all LoDs. The data specification of this reference dataset is provided in the deliverable D2.7 ELF International Boundaries.

European wide classification scheme

Providing geospatial data based on national classifications might not be sufficient for the work at the European level.

INSPIRE generally provides harmonized code lists. There are however some exceptions:

- Land Coverage: INSPIRE contains an empty code list, to be filled by the mapping agency. But INSPIRE has no mandate for common classification.
- The FunctionalRoadClass (road classification) is not really harmonized (number of classes up to each data producer, no definition).

Moreover, even if a European standard existed, another issue might come from the different way to interpret the classification scheme.

Some use cases at a European level have demonstrated the need for a European classification for the road network, for example, in case of mapping purpose. Indeed, national road classifications apply different rules based on geometric-structural or functional parameters, which currently lead to obvious discrepancies between countries when combined in a European coverage.

Unfortunately, no European road classification scheme exists.

EuroGeographics has experienced such interoperability issue on the EuroRegionalMap product for the road classification originated from national criteria. ERM has evaluated the application (mapping of national classification into ERM classification) for each country. Finally, recommendations for the mapping have been provided for several countries. The road classification has been improved in ERM in order to establish a more harmonised and comparable European road network that fits for Basemap application and generalisation purpose.

The next figures show the road network of three countries: Czech Republic, Hungary and Slovakia, before (Figure 4) and after (Figure 5) a reclassification of primary and secondary roads.

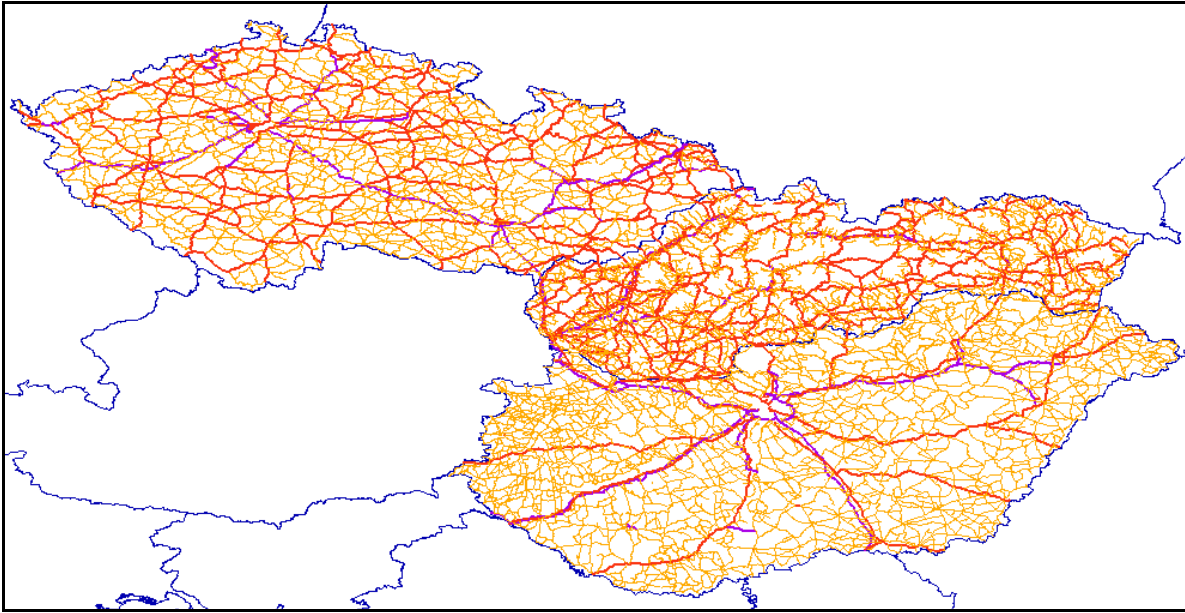


Figure 4: Road classification up to secondary, national classification.

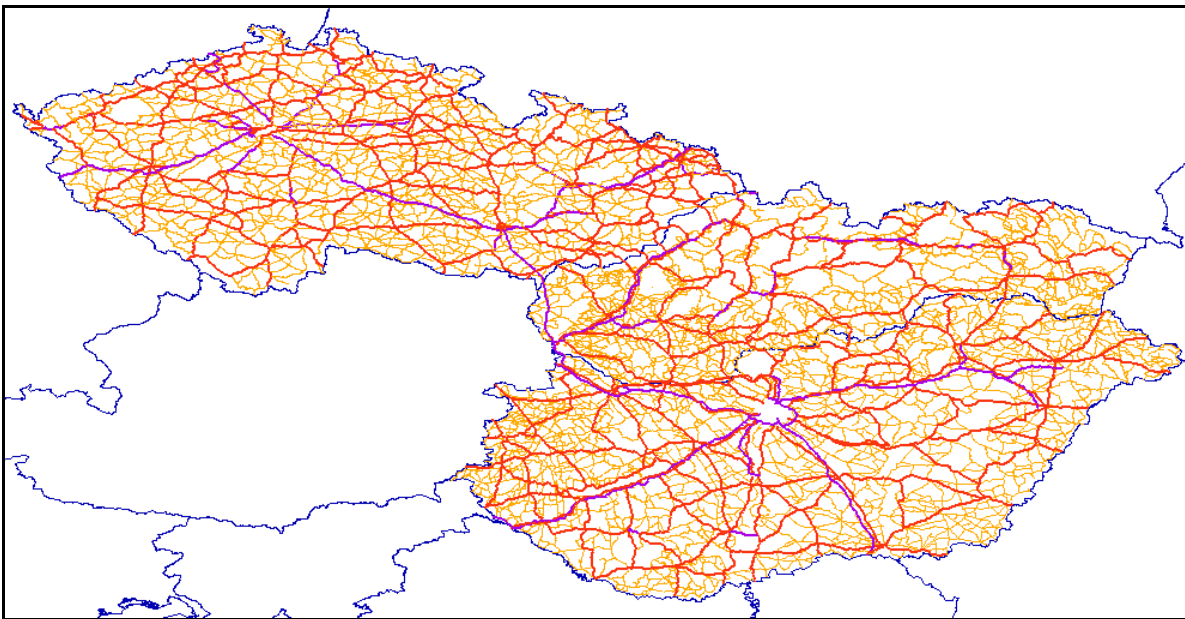


Figure 5: Road classification up to secondary, proposed European classification.

There may be several road classification schemes according to use cases; i.e. in case of Basemap application or spatial analysis; national or European criteria. INSPIRE road classification schema (functionalRoadClass) will be populated based on national criteria. To reach semantic interoperability across Europe, a European road classification schema has to be defined.

Pan-European feature segment

Pan-European feature segments are identified as feature segments used as international boundaries or following them and shared between several nations like some watercourses. The pan-European feature segments should get mutual consent between neighbouring countries for a single representation at all LoDs, which requires:

1. Deciding of an identical geometry,
2. Combining national attribute values whenever different,
3. Populating the INSPIRE-ID. The option taken by the ELF project is to create a new one, instead of combining the national ones. Guidelines to populate INSPIRE-ID at European level are defined in the deliverable D.2.3.2 RulesForPersistentIdentifiersAndLifeCycleInformation.

The following table gives an example of attribute values of the Rhine River segments in EuroRegionalMap used as the international boundary between Germany and France:

Attributes	Values	Comment
F_CODE	BH502	
FCsubtype	Watercourse	
HOC	Natural	
HydroID	E.EG.WATRCRS.000009	
HYP	Perennial/Permanent	
ICC	DE#FR	Combined ICC Values (the feature belongs to both countries)
LDV	inDirection	
LEN	2.598898	
LOC	Fictitious axis through water area	
NAMA1	Rhein	Name (in German) put into alphabetic order according to NLN attribute value
NAMA2	Le Rhin	ame (in French) put into alphabetic order according to NLN1 and NLN2 attribute value
NAMN1	Rhein	
NAMN2	Le Rhin	
NHI	20000000000000000000#A---0000	Combined national values (DE#FR) in case of national identifiers
NLN1	GER	
NLN2	FRE	

NVS	Navigable	
OBJECTID	85238	
Shape	Polyline	
Shape_Length	0.028277	
SN	5050	
TID	Non Tidal	
WCH	First	
WD7	125	
WD8	-29999	

All the countries should keep and maintain these pan-European feature segments in their national datasets. Mutual update maintenance and publication of these pan-European features must be defined and agreed.

The question remains whether the duplication (or triplication) of the pan-European feature segments when published through a national Web Services is an obstacle for any application (i.e. mapping or spatial analysis). If yes, a solution might be that, based on bilateral agreement, only one country will take the responsibility to publish the pan-European feature segment on the ELF platform.

3.2 Impact of the Users

European data specifications are usually set up taken two approaches: the top-down approach driven by the users and the bottom-up approach driven by the data producers.

Whatever the taken approach and the driven party, producers and users should decide of mutual consent for setting up European data specifications, which should be based on already existing data and which should both, meet the user needs and be acceptable for producers in time and cost for data collection and for reengineering national datasets according to the European specifications.

In that perspective, producers and users must cooperate. Providing reliable and authoritative national datasets that fit to European needs and setting up European data specifications accordingly should be a matter of a negotiated process between producers and users in a continuous dialogue.

The approach (bottom-up based) used for the EuroRegionalMap product (ERM), is described as a best practice experience:

- In the first step, the national mapping and cadastral authorities (NMCAs) agreed a European data specification which defined core data content and LoD criteria by starting with their “national” datasets whilst being aware of user’s expectations and provided a first release accordingly.
- In the second step, the producers assessed the quality of the data according to the data specifications, but they also received the users’ analysis (i.e. Eurostat and the European

Environment Agency) which included recommendations based upon their requirements. In the process of a negotiation the producers and users agreed a programme addressing the priorities for improving the harmonisation of the data in an acceptable time and cost for reengineering the datasets. The data specifications were revised and updated accordingly. A new product version was subsequently released which was then again analysed and assessed.

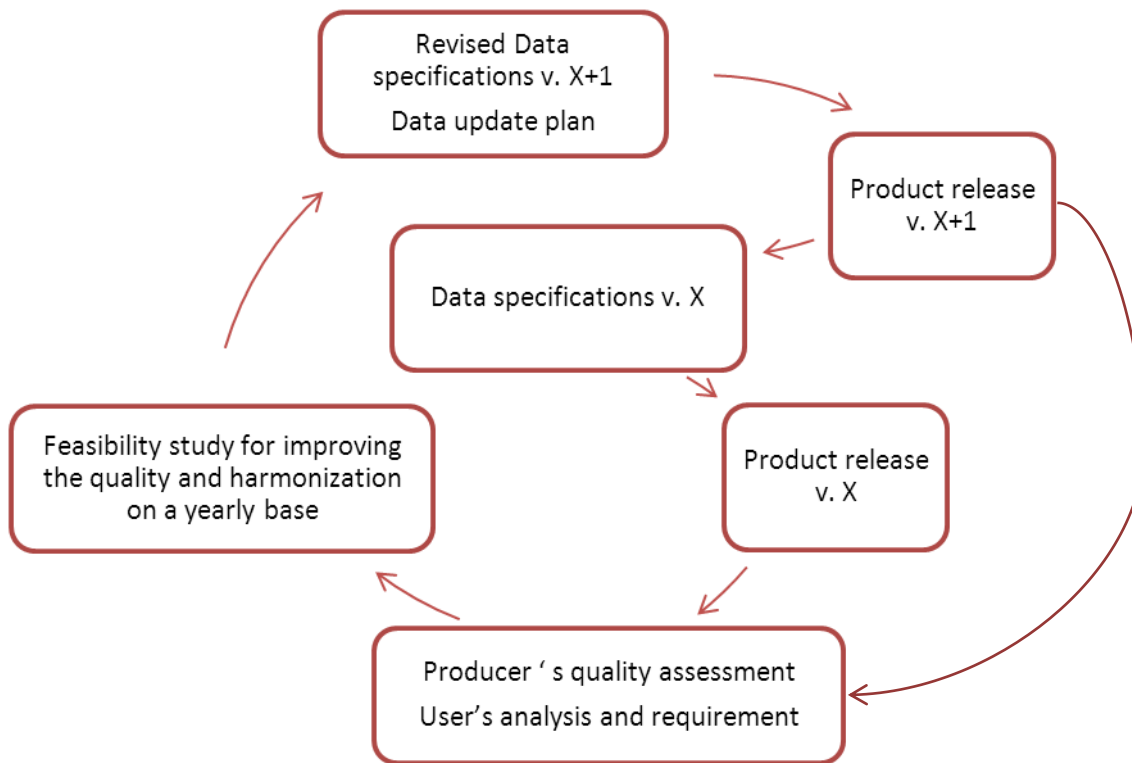


Figure 6: Process for setting up European data specifications

It's a matter of recurring process allowing a step by step harmonisation process of national datasets and the set-up of a pan-European data specification.

The lessons learned for achieving an acceptable quality in data harmonisation are that:

- The data producers are not able to improve the quality and fit for use of their data without a regular feedback of the users. A user feedback at each update or at least every year is required.
- The process may be time-consuming (8 years for ERM) but ensures a sustainable maintenance of the pan-European dataset originated from national authoritative data sources and allows to progressively adapt the national criteria to the European ones at reasonable costs for reengineering.

3.3 Semantic interoperability of the ELF datasets

It is a general objective that the ELF datasets go beyond INSPIRE compliance in the matter of data harmonisation. It is important to estimate which degree of interoperability will be (or must be) achieved on the ELF data in the short, medium and long term.

3.3.1 Short term

The short term fits with the end of the ELF project.

The table below shows the INSPIRE themes that are currently considered in the ELF data:

Master LoD0	Master LoD1/LoD2	Regional	Global
Cadastral Parcels (CP)	Administrative Units (AU)	Administrative Units (AU)	Administrative Units (AU)
Addresses (AD)			
	Statistical Units (SU)	Statistical Units (SU)	
	Hydrography (HY)	Hydrography (HY)	Hydrography (HY)
	Sea Regions (SR)	Sea Regions (SR)	Sea Regions (SR)
	Transport Network (TN)	Transport Network (TN)	Transport Network (TN)
	Geographical Names (GN)	Geographical Names (GN)	Geographical Names (GN)
	Elevation (EL)	Elevation (EL)	
	Land Cover (LC)	Land Cover (LC)	Land Cover (LC) (only for built-up areas)
Buildings (BU)	Buildings (BU)	Buildings (BU)	
	Protected Sites (PS)	Protected Sites (PS)	
		Miscellaneous (MISC)	

At that time, no specific data harmonisation effort will be brought on the ELF data at Master LoD (beside the cluster areas) and the NMCAS will just provide what is currently available.

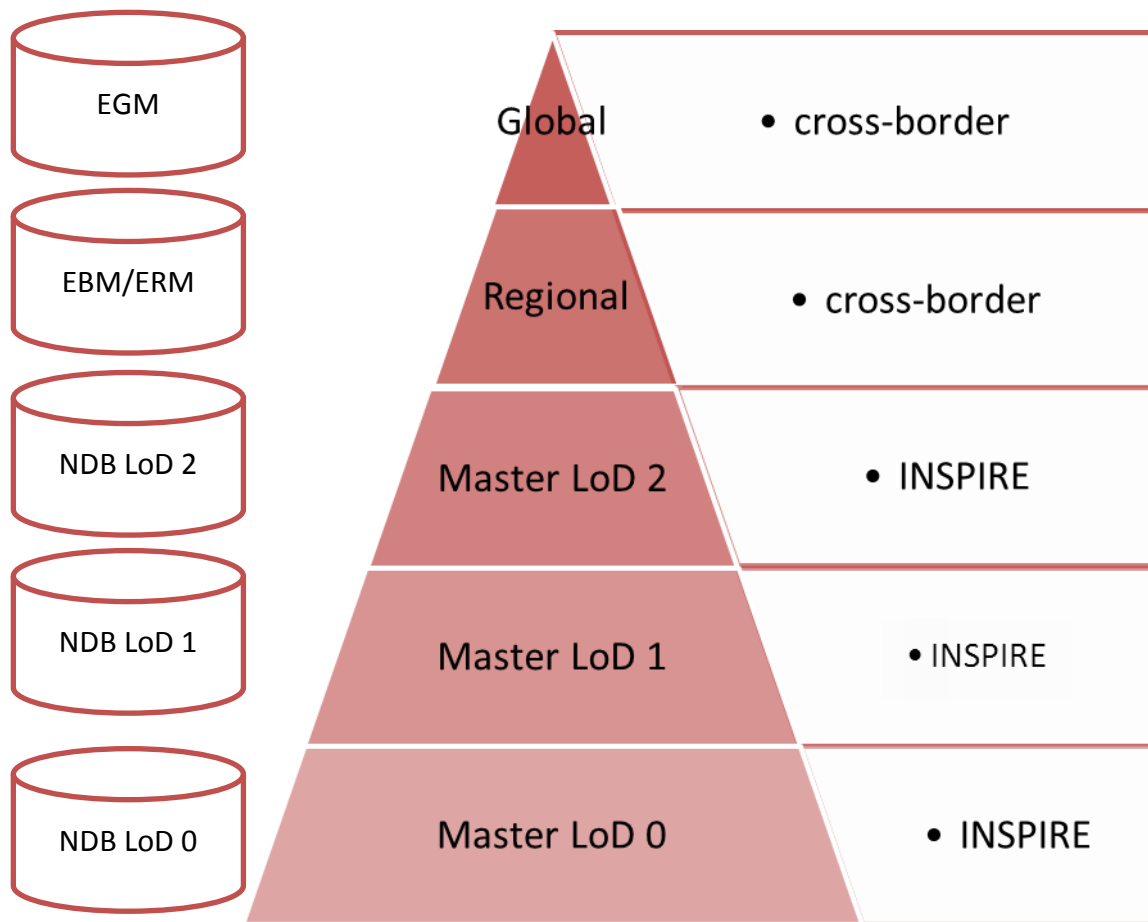


Figure 7: Semantic interoperability at different LoDs, in short term.

At Master LoD, the core data content identified as mandatory features and attributes is still undetermined owing to the lack of clear statement of user requirements at this stage. Indeed most users want to assess the first sets of data that will be made available.

In the first release of ELF products and services the NMCAs will therefore provide their currently available datasets, at Master LoD according to INSPIRE. At Regional and Global LoD, the data will be the current EuroGeographics' pan-European products EuroBoundaryMap, EuroRegionalMap and EuroGlobalMap transformed according to the ELF data Specifications.

By the end of the project the intention is to have improved the statement of requirements based upon the proposition workshop for 10 market segments, the WP7 ELF Awareness Tour and ELF Innovation Awards and the decisions of the WP 9 Core Group.

3.3.2 Medium term

The medium term can be seen as two years after completion of the project when the data harmonisation process when all the outcomes of the ELF project will become operable and applied by at least the EU NMCAs, mainly regarding the adoption of the ELF data specifications, and of the geo-processing tools used for data quality, edge-matching, generalization, transformation, and change detection.

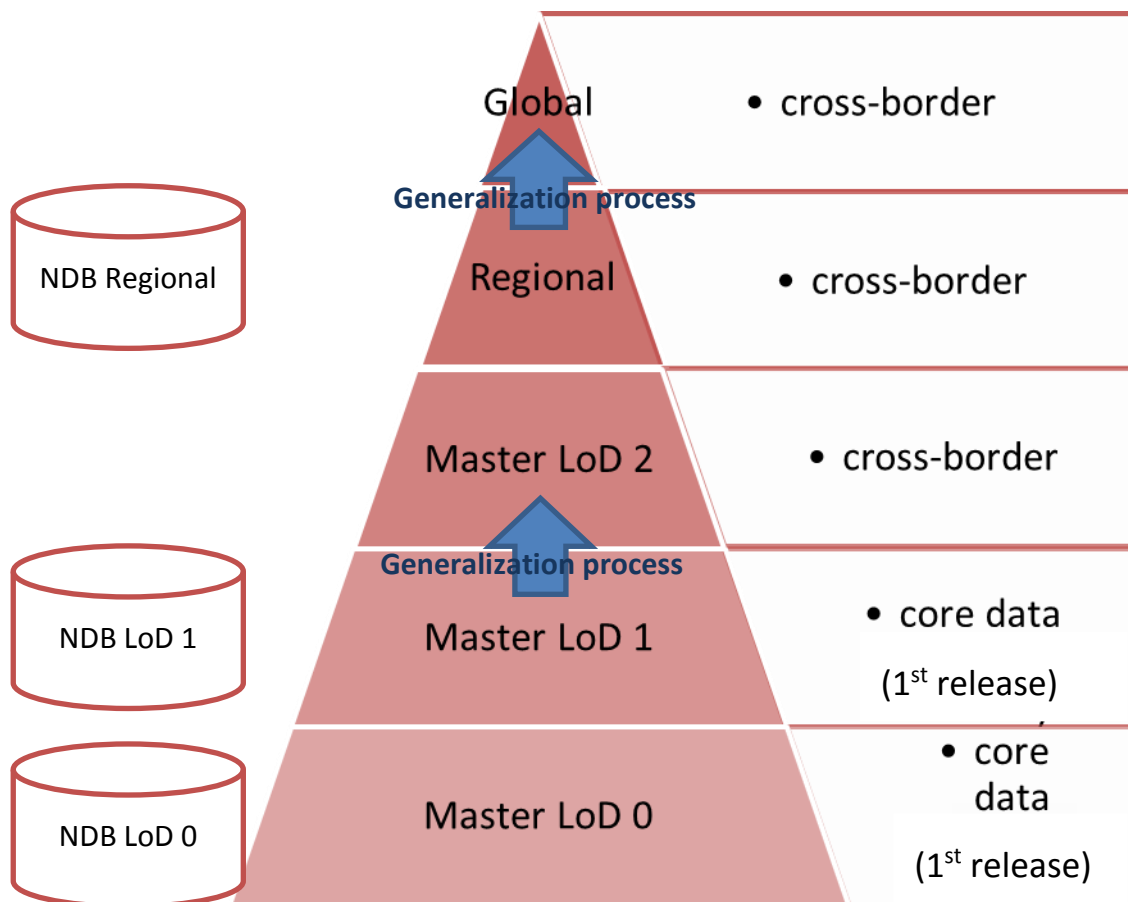


Figure 8: Semantic interoperability at different LoDs, in medium term.

The ELF data will provide core data contents. The cross-border level of interoperability will be achieved for Master LoD 2.

At Master LoD 0 and 1, this core data content will be defined by the feedback of users' requirement and shall fit with what is needed for the generalization at Master level 2. This might be considered as a first release of the core data before again benefitting from user's assessment. The definition of the "core part" of data content will need to be regularly revised based on this feedback (see Figure 6).

Achieving cross-border harmonisation requires some prerequisites in the matter of semantic interoperability. Spatial datasets at Master LoD 0 and 1 will not achieve the interoperability degree of "well defined LoD", which would harm the cross-border perspective. Spatial data specifications at E.L.F. Deliverable D2.3.1

Master LoD 2 have reached a “well defined LoD”, and tools for generalization between Master LoD 1 and LoD 2 will be operable. This will allow the creation of new datasets at Master LoD 2 derived by generalization from Master LoD 0 and 1 and reaching a suitable cross-border degree of interoperability.

Acquiring agreed international boundaries (ELF IB) at very high level of precision (treaty level) is an on-going project of EuroGeographics but will not be achieved during the project. The result is that ELF IB dataset will be a mixture of LoDs based on what is available.

Spatial datasets available at Regional and Global LoD have already fully achieved the cross-border level to meet identified user requirements. The spatial datasets at Global LoD are semi-automatically derived from the Regional LoD by a generalization process.

Acquiring and collecting core data content at Master LoD 0 and 1 will take a number of years. This is the prerequisite to obtain a cross-border dataset at Master LoD 2, which will serve as reference data in future for deriving the Regional and Global LoD.

In the meantime, the ELF data at regional and global LoD will be updated and maintained separately by aggregating national data sources with a different content than for the Master LoD.

3.3.3 Long term

The long term is based upon evolving user requirements, where the ELF data will need to meet the user's applications. All suitable information should be collected and implemented at the Master LoD 0 and 1.

According to the user requirements, the Master LoD will provide the core content, required by most applications and available on a full European coverage. Additional themes and information will be required. Data providers other than NMCAs will be invited and encouraged to populate the ELF/INSPIRE data models or at least the “core” part of it.

The Master LoD would enable spatial analysis applications on a European coverage and therefore achieve the cross-border degree of interoperability. However, reaching such level of interoperability at Master LoD 0 and 1 for a European coverage may prove to be unrealistic, even in the longer term, owing to strong and irreconcilable national constraints in data collection and update and excessive costs for reengineering the data according to European mutual consent.

However, if required for a specific usage, the cross-border degree of interoperability at Master LoD 0 and 1 might be applied in limited areas between a group of countries, which will then take the responsibility to set up their own rules of data harmonisation.

Based on the trusted core data content available at Master LoD 0 and 1, it will be possible to derive a generalized dataset at Master LoD 2, cross-border, and fitting the requirements for most of the applications requiring a European coverage.

The Regional and Global LoDs will be derived from Master LoD 2 by generalization process.

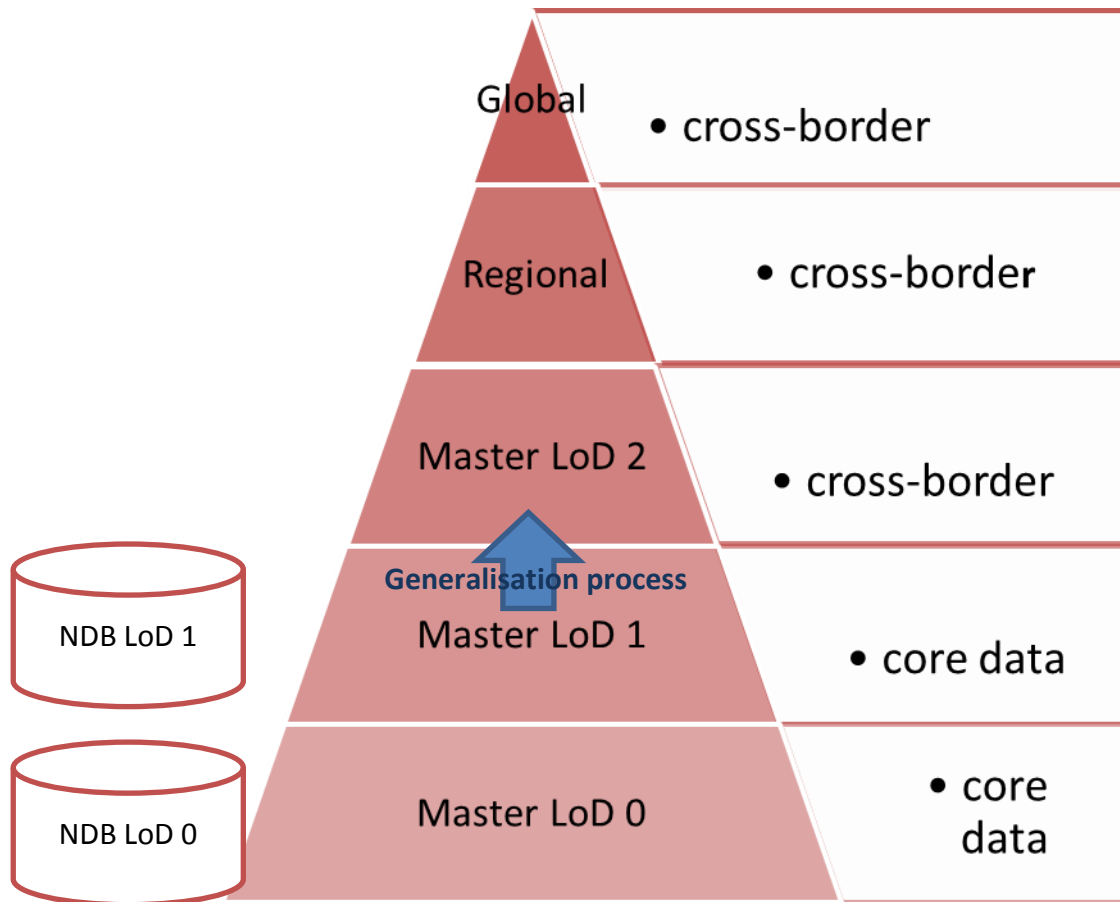


Figure 9: Semantic interoperability at different LoDs, in longer term.

4 Organizational Interoperability

As soon as the spatial datasets will be made available on the ELF platform, they will be subjected to user's analysis and their expectations and requirements will need to be collected. It is likely that:

- Additional data will be required.
- Improvements in the core data content, data quality and data harmonisation will need a continuous dialogue between users, the ELF Platform Manager and data producers.

In that perspective, the ELF data content might be regularly revised and updated in future according to European user needs and a costs benefit assessment. The ELF Platform Manager will need to establish the organisational processes for updating ELF specifications and for maintaining the ELF data. The challenge will be to determine which part of the user's requirements for ELF data can be met by the data producers and which part will be out of scope of the ELF platform and left to application developers to satisfy.

Chapter 4 describes a number of options for producing and maintaining ELF data in case of increasing content of required information.

4.1 Option 1: ELF data = core Reference Data of NMCAs

A general objective is that the ELF platform will, at least, make available the authoritative data produced at national level and provided by the NMCAs. By this, we mean "the officially recognized data that can be certified and provided by an authoritative source. In the context of public agencies, authority is the legal responsibility provided by a legislative body to conduct business for the public good." (Ref [4]). These data are initially captured and kept up to date by the NMCAs (through several decades). These data are usually acting as reference data (to be used as reference for all kind of themes). Some INSPIRE themes that can be considered to be part of the core reference data are not produced fully by the NMCAs in some countries. Therefore this option will have limited success for example in transportation theme.

The ELF data are limited to the core Reference Data usually produced and maintained by the NMCAs. Additional data coming from other public bodies or private companies are produced and maintained at another level of responsibility and outside the ELF platform. The task for integrating or linking additional data will be with the data/services providers.

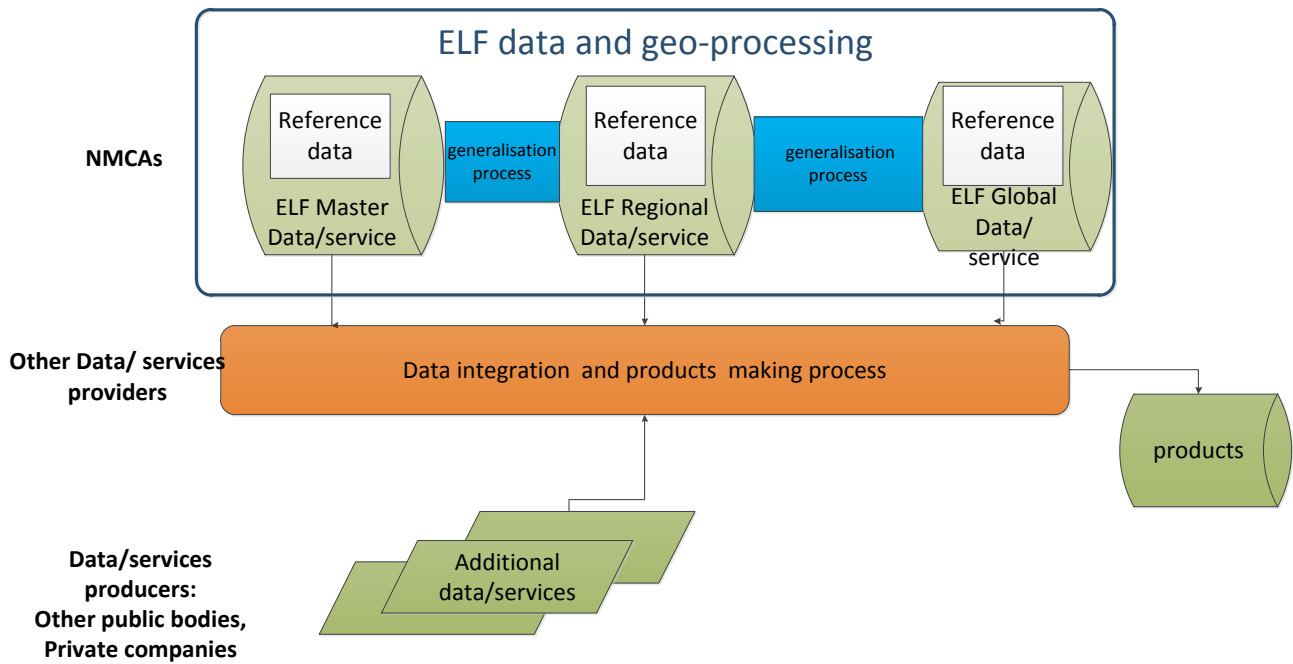


Figure 10: ELF data and geo-processing based only on NMCA's Reference data

In that case, as NMCA is solely responsible for producing a data theme, it will be possible to achieve the long term vision in matter of data harmonization process where the core data content will be collected and update at Master LoD 0 and 1 and will serve as reference for deriving the lower LoDs by generalization.

This option is the easiest approach for NMCA's targeting on quality and maintenance of their reference datasets. However the expected results will not meet the long term user requirements.

4.2 Option 2: ELF data = core Reference Data of NMCAs + additional data

A chosen selection of additional data will be part of the ELF data as well. The ELF WP6 on users and third party data content has identified several possible additional data:

- Land use
- Sea regions
- Orthoimagery (ortophotos)
- Polygons of Postal codes
- Socio-economic statistics
- Demography statistics
- Health statistics
- Hazards data - flood risk zones
- Hazards data - ground instability (subsidence, earthquake)
- Hazards data - windstorms
- Hazards data - wildfires
- Hazards data - crime
- Trees
- Soil data
- Utilities and Governmental Services - hospitals, Emergency Medical Services
- Utilities and Governmental Services - primary and secondary schools, universities
- Disposal Site /Waste Pile: An area for the collecting / disposing of refuse or discarded material
- Energy resources: Power Generation, power lines (electricity grid), pipelines (oil, gas)

Very few of these themes can be provided by NMCAs and will need to be provided by other public bodies, (or private companies if they meet the criteria for authority). Also in some countries certain core reference themes, like transportation, are not fully provided by the NMCAs.

The criteria to determine which additional data will be integrated into the ELF data is out of scope of the current project. However it is obvious that the ELF data content will evolve increasingly according to applications and user interests.

In [4] we see that user requirement usually surpass what NMCA reference data can provide and raised a similar question. “What cGRD are maintained by NMCAs as authoritative and reference data, what information is considered as additional and how additional data production and maintenance will be organized?”

Adding new information will require an additional processing in data integration i.e. by linking statistics or health information to the reference data of NMCAs. The data integration process might be in charge of the NMCAs.

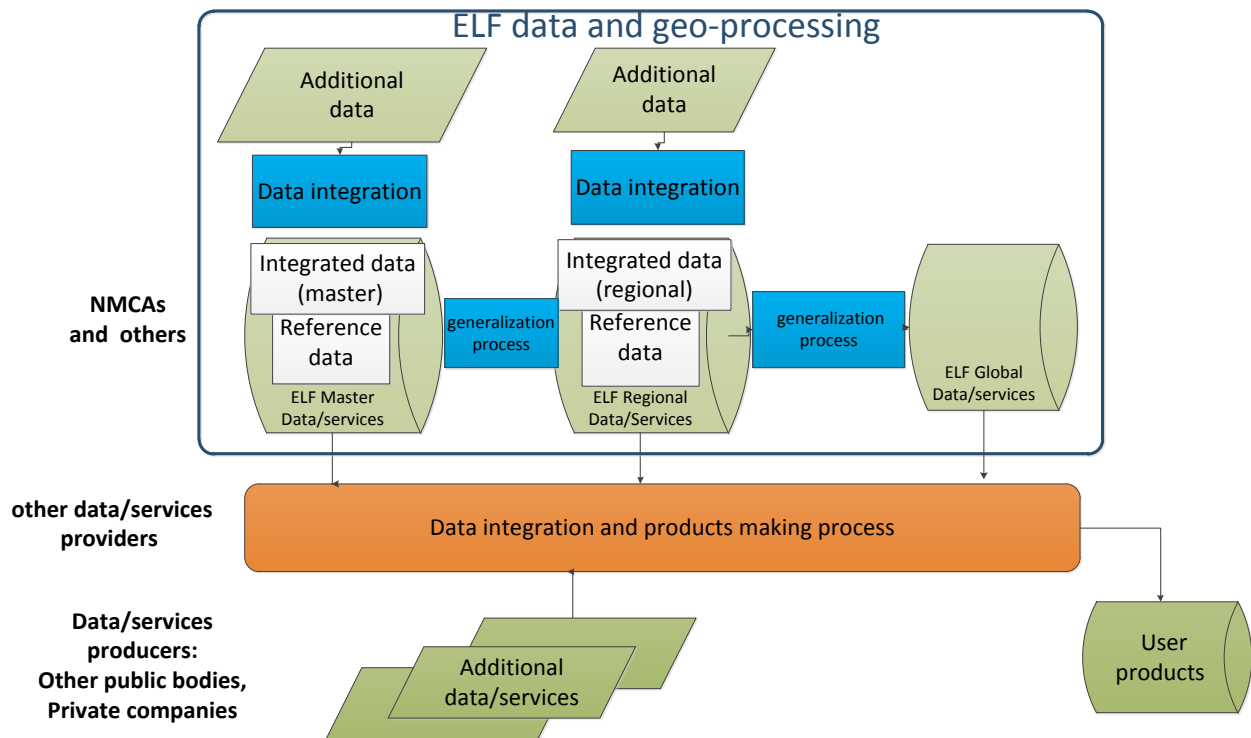


Figure 11: ELF data and geo-processing based on NMCAS Reference data and additional data

In that case, the ELF data content will be user-driven according to use cases and applications. This might imply that the information required in priority is not necessarily available or capable of integration at Master LoD 0 and 1. The ELF core data content will vary at different LoDs according to user needs and applications.

This impacts the maintenance of the ELF data specifications extension and geo-processing tools requiring regular update.

However we must already assume that a part of the data required by specific users will surpass NMCAS' business in matter of data capture or data integration and therefore be excluded from the ELF data content.

4.3 Recommendations

The option 2 is recommended if we want to ensure a sustainable maintenance of data that fit user's needs and applications (like the EG products), which implicates that:

- Many NMCAs then, need to revise their strategy in data update and maintenance, not only being focused on collecting and producing authoritative and reference data and acting as data and services producers ³ by extending their capacities to integrate additional data and making them available on Web services.

One of the key risks is that even if an agreement has been reached on the definition of the ELF data content, some NMCAs might not be able to fulfill the provision of the ELF data. The countermeasure is to extend the partnership to other public bodies or private companies able to complete and supply the missing data to the ELF platform.

- Regular updates and maintenance of the ELF data specifications and the geo-processing tools have to be considered and coordinated (as well as the ELF platform architecture).
- Because of the many facets in the development of ELF platform, and because of so many partners involved, there is strong need for coordinating activities and for a decision-making process able to regularly evaluate and define the content of the ELF data.

³ The difference between data/service producers and data/service providers is subtle. While the producers really have a role as data custodian (it is in their mandate to produce and maintain data/services), the providers are those entities that throughout their day-to-day work processes create data/information as a process output or outcome.

5 Technical Interoperability

This chapter will be restricted to the technical interoperability regarding ELF data processing and tools and not regarding the technical architecture and services.

The technical interoperability shall ensure proper ELF data workflow starting from national data sources to their publication in Web services and including the proper use of the geo-processing tools in quality, edge-matching, change detection and generalization. This process is referred to as the data supply chain.

The data supply chain will depend on the required degree of semantic interoperability of the ELF datasets (see chapter 3), which is to be cross-border.

5.1 Data Supply chain, Cross-border

The data supply chain illustrates the different geo-processing steps in the aim to achieve ELF cross-border level of the national datasets.

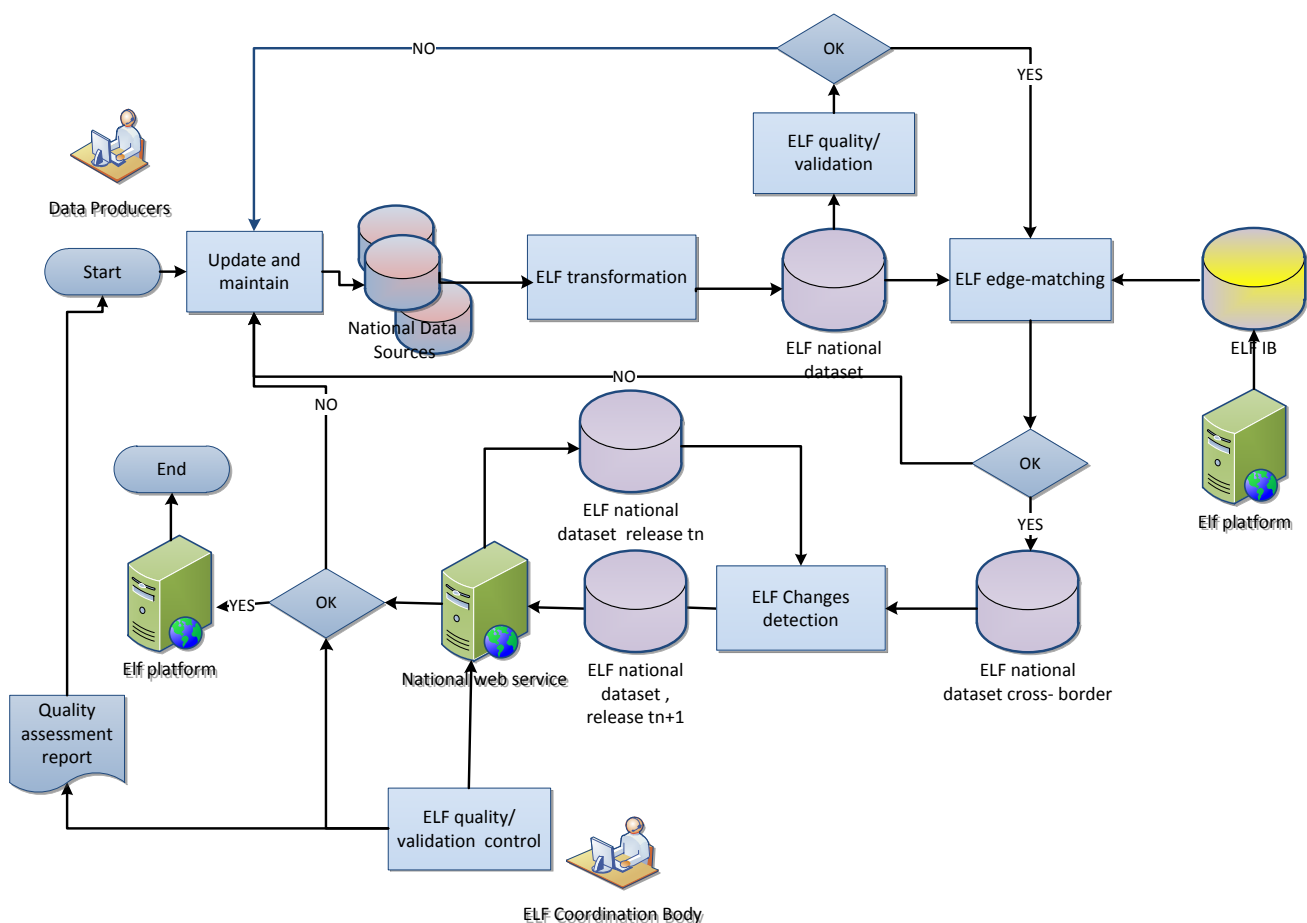


Figure 12: Data supply chain, cross-border

1. **ELF transformation process:** In principle, the geo-processing tools are implemented for running on ELF compliant data. Therefore, the ELF transformation process is the first step,

transforming the national data sources from national schema into ELF schema (D2.3.4 Transformation).

2. **ELF Quality/Validation process:** The process validates the compliance of the ELF data with the ELF data specifications and schema. This process can run at any time in case of update or correction on the ELF data. The process, at the end, provides metadata on the data quality like a reporting on ELF compliance and statistics on data content (D2.3.6 Quality).
3. **ELF edge-matching process:** To achieve the cross-border level of interoperability, the ELF national component must be edge-matched properly on the ELF International Boundaries (ELF IB), by following the guidelines on the edge-matching procedure and using the geo-tool. The ELF IB database shall be downloadable from the ELF platform (D2.3.3 Edge-Matching).
4. **ELF change detection process:** This process regulates the sustainable maintenance of the INSPIRE-Id and lifecycle information by comparison between two releases (T_n , T_{n+1}) for the same dataset and detects the changes in data updates which have occurred between two releases. In tracking updates, the change detection process should be run as the last step, when no more correction or modification is brought on the ELF data (D2.3.2 RulesForPersistentIdentifiersAndLifeCycleInformation).

The change detection process shall be used in case no inspireId and lifecycle information are properly maintained in the national data sources or for datasets derived by the ELF generalization process.

The four processes are fully in the charge of the NMCA's.

However to ensure a good quality maintenance of the data supply, a coordination body will proceed a final quality validation of the ELF data.

The quality/validation procedure of the coordination body will check the level of data interoperability defined for each LoD for a European coverage and applications usage. The coordination body will provide regular feedback to the data producers in order to improve the quality of their data in the matter of data harmonization.

The coordination body may refuse to include data in the ELF platform in case the quality rate of the ELF data is inconsistent with defined standards.

The quality/validation procedure of the coordination body will mainly be based on the data quality metadata provided by the data producers and automated quality tests and on visual checks probably done on the Web services. Nevertheless in case of inadequate response by the data producer the coordination body should be able to get access to the ELF national data and run the quality tools on the ELF data for a deeper quality control.

Other tasks of the coordination body are:

- to ensure the update of the ELF International Boundaries (ELF IB);
- to ensure the update of the ELF data specifications and of the geo-processing tools.

The national components of the ELF cross-border datasets (of all LoDs) will be published through the national Web services.

5.2 Data supply chain, generalized dataset

The ELF generalization process aims at deriving (mostly) automatically generalized ELF datasets from ELF datasets of a higher LoD, coming from the official releases published on the ELF platform. (D2.3.5 Generalisation)

ELF implements two generalization processes, one from Master LoD1 to Master LoD2 and one from Regional to Global.

The generalization process from Master LoD1 to LoD2, at that stage, remains at a generic level with the delivery of generic rules selection for Master LoD2 and generic tools. The producers will have then to customize their own generalization process according to national criteria.

The generalization process from Regional to Global is at a mature level. It will apply the automated generalization process developed for the EuroGeographics product EuroGlobalMap to the ELF Regional to Global generalization step. The data supply chain for the ELF generalized datasets is then based on this best practice experience (see Fig 13).

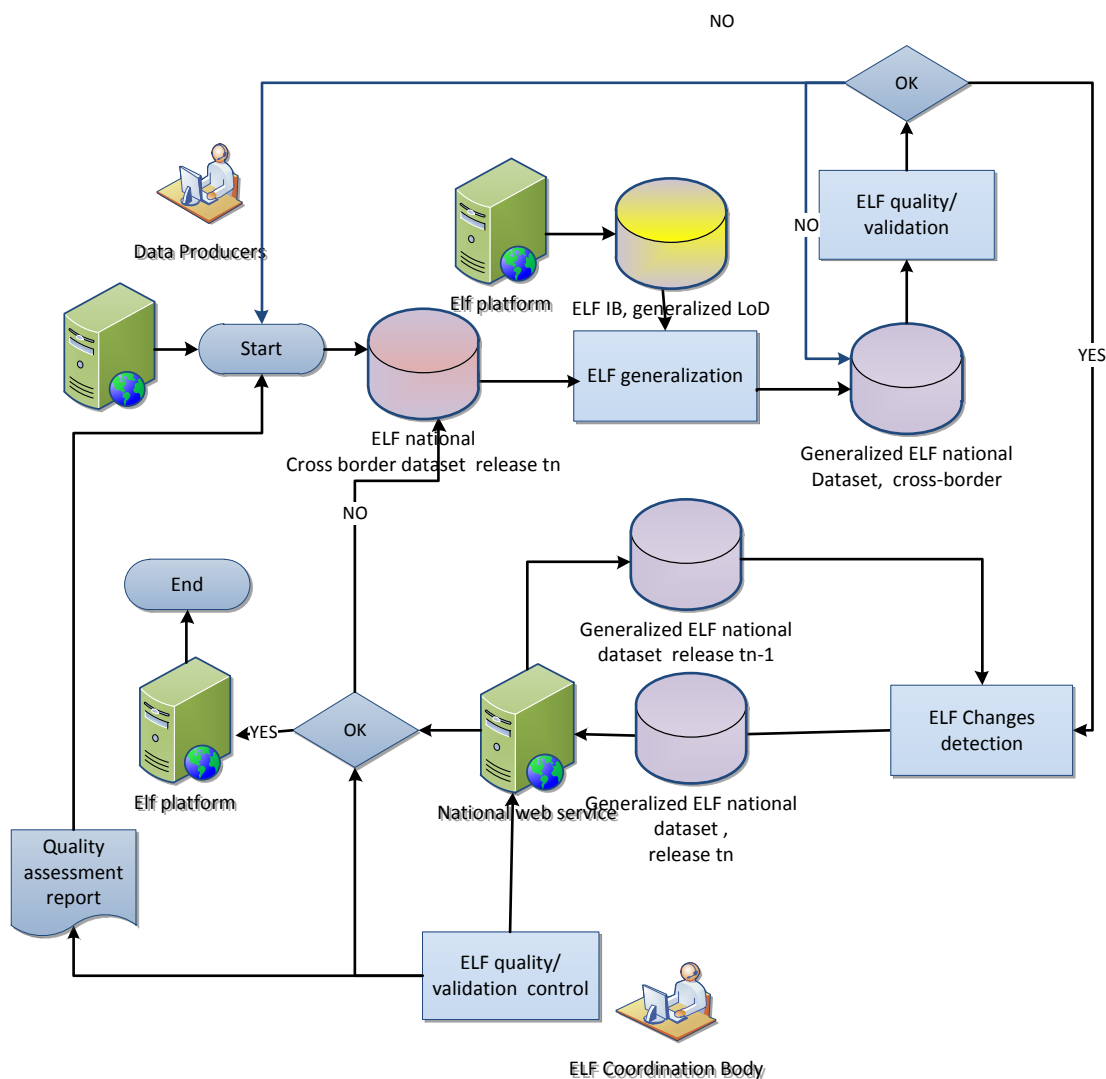


Figure 13: Data supply chain, generalized datasets

ELF generalization process: The developed tools allow an automated generalization process on pan-European coverage. The process ensures a proper edge-matching to the ELF international Boundaries set up at the generalized LoD.

ELF Quality/validation process: The process is mostly automated and currently cannot avoid some errors to check and to correct on the generalized dataset. Moreover, the generalization rules cannot take into account national specificities requiring an adaptation of the implementation at national level.

ELF Change detection process: As the generalization process will not integrate the persistent identifiers (inspireId) and lifecycle information, the change detection process must be used.

5.3 Applying ELF technical interoperability principles

The technical interoperability principles adopted by ELF are the following:

- The geo-processing tools shall be able to run on ELF compliant data sets.
- INSPIRE/ELF GML will be used as the standard for data exchange on the ELF platform.

5.3.1 Implication for the geo-tools implementation

Several tool developers are involved in the implementation of the geo-processing tools:

Tools	Tool developers	Used Software
Data quality Validation	ESRI	ArcGIS
	1Spatial	1Spatial Cloud
	Delft University	pprepair and ppprepair
Change Detection	IGNF	C++ libraries
Edge-Matching	ESRI	ArcGIS
	1Spatial	Local installation of 1integrate with ELF Edge Matching Rules
	Delft University	pprepair and ppprepair
Generalization (Regional-Global)	IGNF	C++ programming based on IGN-F internal libraries
Generalization (master LoD1-master LoD2)	1Spatial	Local installation of 1Generalise with specific Flowline
	Delft University	tGAP builder (prototype implemented in Python)
	KadasterNL	ESRI ArcGIS
Transformation	Snowflake	GO Loader and GO Publisher

A survey inquiring (see Annex 1: Inquiry on geo-processing developed by the ELF tools providers) on tools implementation and possible constraints for applying the ELF technical interoperability principles has been set up with the following questions:

- What exchange data formats currently used for input and output?
- Which internal data format is used for geo-processing?
- Are tools compliant to ELF specifications, what are the readable data formats (GML, other?)
- Are tools compliant to other data schemas and specifications

In summary, the internal data format is customized to each tools developer, the most commonly used exchange data formats are Shapefiles and SQL databases PostgreSQL , Oracle.

Regarding the geo-tools to run on INSPIRE/ELF data schema and specifications: All tools will be able to run on ELF compliant data sets (but are not restricted to).

Regarding the use of INSPIRE/ELF GML as exchange data format: Currently no tools are able to work directly on GML data format. INSPIRE/ELF GML data have to be imported to workable data format used for the geo-processing.

- 1Spatial and Delft University are developing tools allowing the use INSPIRE/ELF GML exchange data format. Delft University will restrict the GML importing /exporting to simple features.
- ESRI proposes an extra-process using the ArcGIS Interoperability Extension, for importing and exporting INSPIRE/ELF GML.
- IGNF will not develop INSPIRE/ELF GML extension. The changes detection is currently implemented on simple features (in first step).
- Snowflake will provide transformation tools able to export INSPIRE/ELF GML but not to import INSPIRE/ELF GML.

In the light of the current implementation of the geo-tools, we can detail the geo-processing steps on the data supply chain when using INSPIRE/ELF GML as exchange data format.

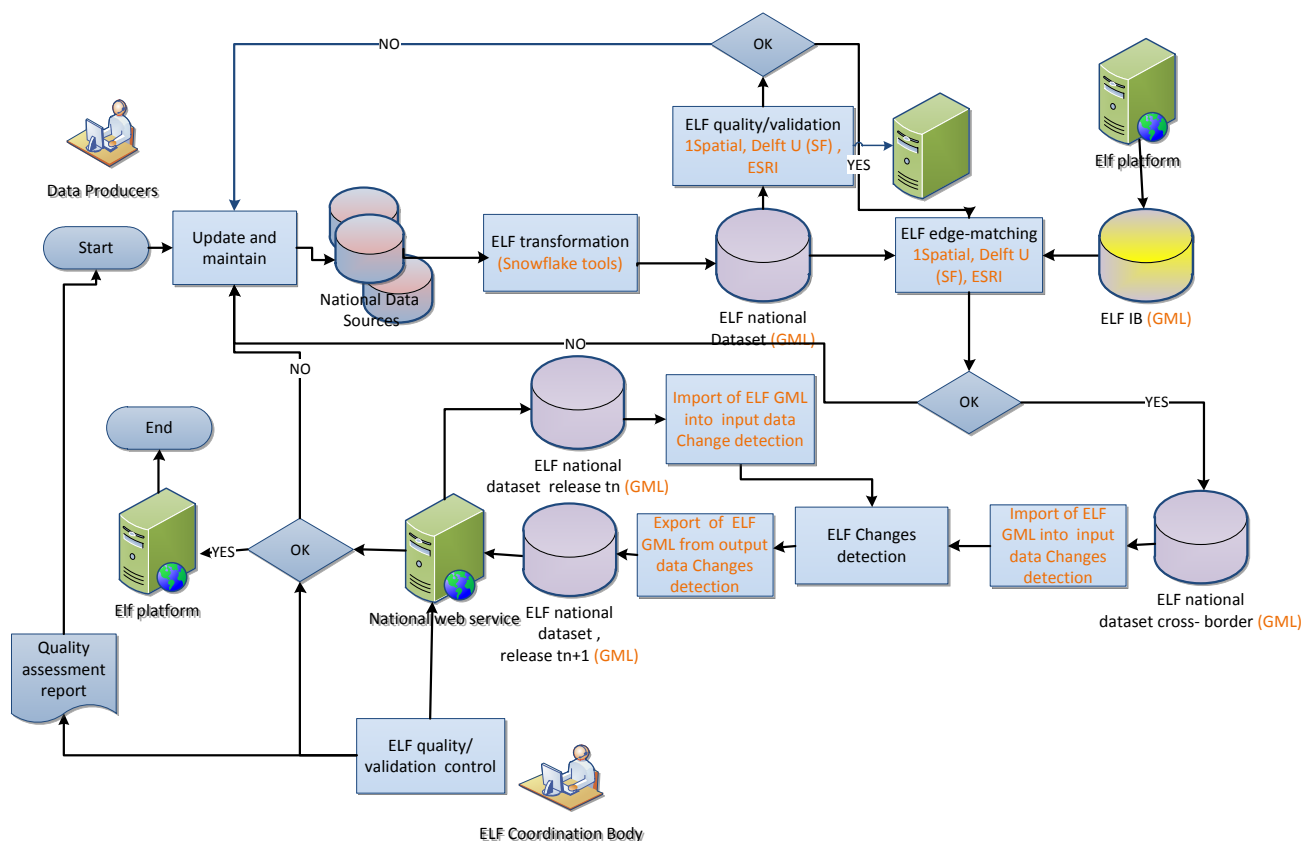


Figure 14: Data supply chain with INSPIRE/GML as exchange data format

Currently the implementation of one processing step is missing, which is the import/export process between INSPIRE/ELF GML and the internal data format applied for the ELF change detection.

5.3.2 Implication for the Web Feature Services

Currently, the Web Feature Servers, implemented by some software like Geoserver, Deegree ESRI ArcGIS INSPIRE or Intergraph Mapserver, have usually access to data mapped in their own internal data format (relational-base). They require an additional processing step to import the ELF/INSPIRE GML.

The ELF project has already experienced the process of importing INSPIRE/ELF GML on national Web Feature Server. Two test cases are presented: one from IGN France and one from BKG Germany.

IGNF uses Deegree to publish the ELF data on WFS. Two processes have been tested.

One process is to use the data delivered in INSPIRE/ELF GML data format by Snowflake, whose files reached 1 to 2 Gigabytes size. The tested themes are the transport, addresses and hydrography for a French department. However the import of the ELF/GML files into Deegree has been problematic. Currently, the loading of INSPIRE/ELF GML data on addresses crashed. The invoked reason was that the internal relational data structure (PostGIS) used by Deegree has not been able to integrate the elaborated INSPIRE/ELF data model structure.

The other process is to transform internally the IGN-F data directly into a PostGIS database INSPIRE compliant and named “INSPIRE-like”. This database is directly readable by Deegree. The tested themes are the administrative units, the geographical names and the addresses. IGNF will opt for this solution in longer term. Finland has taken a similar approach.

The test case of BKG Germany has been to publish the administrative units of ELF regional on WFS. Two processes are tested: one process (1) uses ArcGIS for INSPIRE and transforms the INSPIRE/ELF GML into ESRI File GDB, and another process (2) transforms INSPIRE/ELF GML into PostGIS for further services, by using Snowflake GoLoader.

BKG has also taken in charge the process for mapping the EuroBoundaryMap File Geodatabase (ArcSDE) into INSPIRE/ELF GML data by using GoPublisher (Snowflake).

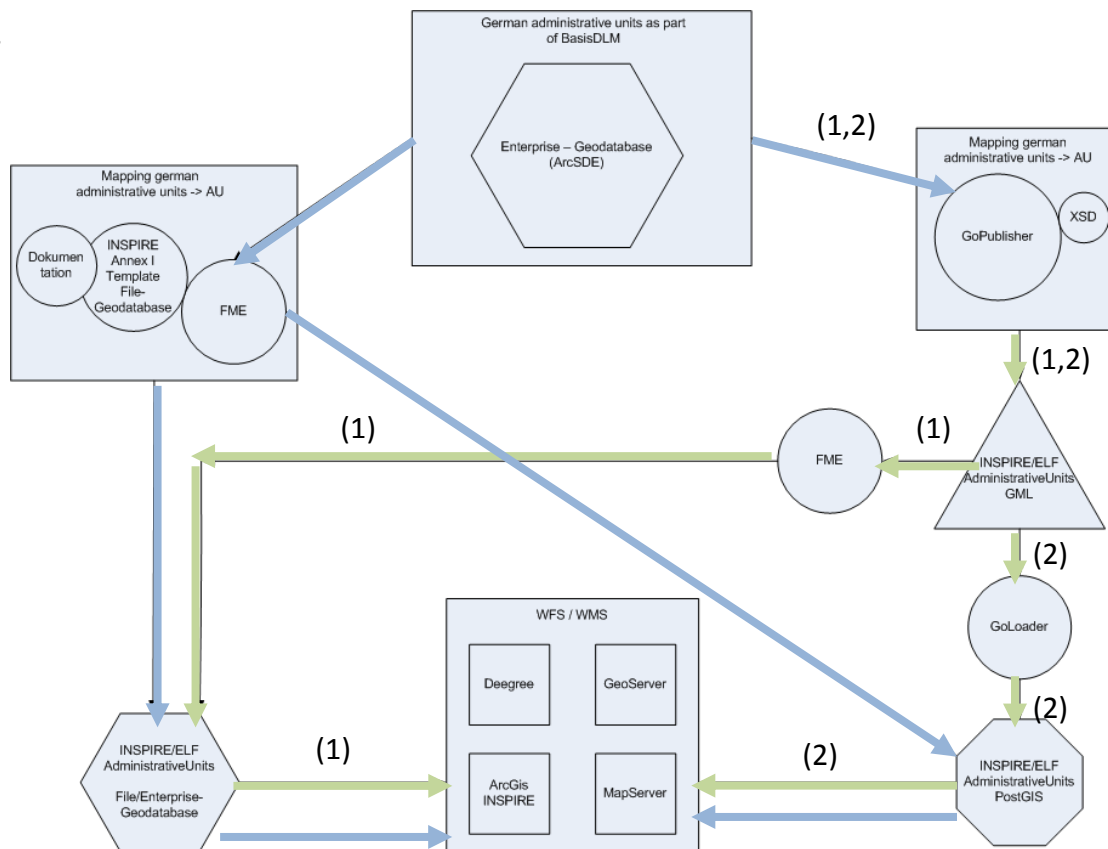


Figure 15: Processing steps for publishing ELF Regional administrative units by WFS

Green – two processing steps working on ELF/GML exchange data format. Blue – alternative way working on non-GML data format.

The experiences are the following:

- The GML file size (7660 Mbytes) was not such a problem but has been very long to generate from an ESRI File Geodatabase (523 Mbytes). It took over 8 hours for creation.
- GoPublisher is powerful but requires knowledge and experience for the tools usage.
- Transformation process from ELF/INSPIRE GML into PostGIS was not easy going, tackling with a lot of issues.
- BKG would have preferred to follow the non-GML way.

5.3.3 Implication for the base map application

Ideally the base map application will use the ELF data made available on the national Web Mapping Services, but the WMS servers can't read GML. In addition, some INSPIRE themes have a very complex data model that is not suitable for mapping purposes. Typically, the mapping process cannot support the Transport (TN) properties as feature types attached to geometry by linear referencing. This requires generating a simplified modeling of the data as input to the Web Mapping Servers.

5.3.4 General finding and conclusions

The principle of technical interoperability requiring to work and process on a standard data model and schema (ELF) is commonly agreed and will be implemented by the tools providers.

Defining a standard data format for exchanging data is also a key condition for ensuring the technical interoperability in matter of geo processing and publication at European level.

When choosing the INSPIRE/ELF GML data format, some findings are:

- The INSPIRE/ELF GML data modeling is a little bit too advanced to be easily integrated into most of the GIS software and tools. Nowadays, the GIS world effectively uses flattened data structures, style relational data bases and import INSPIRE GML data into their workable data physical format. The issue is not so related to the GML format as such but well on the high-level elaboration of the INSPIRE data modeling implying additional implementation aspects that are not so easy to reflect from a physical data structure in a “relational” database.
- Moreover the geo-processing tools implicating modifications of the data like generalization, changes-detection and edge-matching currently run on simple features.
- The resulting file size is not a big problem, but slows down the geo-processing when working on pan-European coverage or on a national coverage and loses efficiency on recurring processes like the validation/quality process.
- The INSPIRE UML data schema and modeling are great to represent the information in an elegant way, but are sometimes disconnected from the intended use of the data like providing elaborated web mapping application.

One of the key questions is: What will be the workable and interoperable data format of the ELF data sets to be used for the ELF geo-processing in the data supply chain, starting from the national data sources to the publication on national Web services?

Does ELF adopt the INSPIRE/ELF GML as the only standard for data exchange (the only one proposed by INSPIRE) and that way pushes forward the geo-processing implementation and development?

And/or, does ELF consider alternatives?

6 Main findings and conclusions on achieving data interoperability

In the light of the best practices and experiences in the matter of pan-European production workflow, the document has set up a stepwise approach for achieving semantic data interoperability with the aim to reach ELF cross-border datasets able to meet users' needs and applications.

The cross-border level of interoperability providing pan-European coverage will not be achievable even in longer term at Master LoD 0 and 1, mainly owing to data availability and the national constraints for collecting and updating the data, but well for derived datasets at a lower level of details.

The ELF core data will be user-driven and will probably be extended in future with additional data. This will require regular maintenance and update of the ELF data specifications and of the geo-processing tools.

The document has analyzed the technical interoperability looking at a suitable way to supply ELF data from the national data sources to their publication on web services and how to integrate the different geo-processing like quality/validation, edge-matching, generalization, and changes detection.

The ELF principle of data interoperability fully support the INSPIRE principles. However, their application in the matter of ELF geo-processing interoperability has revealed some difficulties with procedures, which could lead to the risk of being rejected by the data producers.

The update and maintenance of the ELF national data made cross-border will be fully under the responsibility of the data producers. However to ensure acceptable data quality and for a sustainable maintenance of the ELF data covering Europe, ELF must ensure an overall coordination of the data supply chain onto the ELF platform, which will look at appropriate data quality fitting user's needs; the update of the ELF International Boundaries (IB); the maintenance of the ELF data specifications and of the geo-processing tools.

The main conclusions and findings are based on the current test cases of the ELF project and the pan-European production of the EuroGeographics products. This doesn't mean that those conclusions are definitive but will evolve in the light of best practices and experiences gained until the end of the project.

Annex I: Inquiry on geo-processing developed by the ELF tools providers

Tools	Service providers	Software	Exchange input /output data format	Working data format	ELF compliancy	GML modalities
Data quality Validation	ESRI	ArcGIS	shapefile, geodatabase, SQL database (Oracle, PostgreSQL, etc)	ESRI geodatabase	read ELF data (in flattened relational schemas) directly from other databases, such as PostgreSQL, as well as directly reading common de-facto standard formats such as shapefile	read ELF data GML via the ArcGIS Interoperability Extension.
	1Spatial	1Spatial Cloud	INSPIRE GML/ <u>shapefile</u>	Proprietary object database, although this is entirely transparent to the user	The underlying tools can be configured to work with a range of technologies and schemas. At the moment they are configured to use INSPIRE GML as that is the only GML format for which we have been able to obtain sample data.	only INSPIRE GML format for which we have been able to obtain sample data
	Delft University	prepair and pprepair	any OGR format (http://www.gdal.org/ogr_formats.html) Shapefiles,WKT	a constrained triangulation stored in the CGAL data structure	can read ELF GML	Any GML 3.x that can be translated into Simple Features
Change Detection	IGNF	C++ libraries	postgreSQL	postgreSQL	actually the tool works with simple object in postgresQL (object with one or more geometric column). The tool work with any data schema (only simple feature). The tool need flattened structure:	GML is not implemented

Tools	Service providers	Software	Exchange input /output data format	Working data format	ELF compliancy	GML modalities
Edge-Matching	ESRI	ArcGIS	shapefile, geodatabase, SQL database (Oracle, PostgreSQL, etc)	ESRI geodatabase	read ELF data (in flattened relational schemas) directly from other databases, such as PostgreSQL, as well as directly reading common de-facto standard formats such as shapefile	Read ELF data GML via the ArcGIS Interoperability Extension.
	1Spatial	Local installation of 1integrate with ELF Edge Matching Rules	Supports a wide variety of input formats. The ELF Edge Matching Rules will be developed and tested using ELF GML input/output	Proprietary object database, although this is entirely transparent to the user	Yes (current development is using INSPIRE GML data, until ELF edge matching requirements and sample ELF GML data is available)	current development is using INSPIRE GML data,
	Delft University	prepair and pprepair	any OGR format (http://www.gdal.org/ogr_formats.html) Shapefiles,WKT	a constrained triangulation stored in the CGAL data structure	can read ELF GML	Any GML 3.x that can be translated into Simple Features
Generalization (regional-Global)	IGNF	C++ programming based on IGN-F internal libraries	PostgreSQL	PostgreSQL	The tool only takes into account ELF feature classes which correspond to existing EGM data (simple features only)	the tool will not take GML as input format, we work only on a flattened structure in PostgreSQL format
Generalization (master lev1-master lev2)	1Spatial	Local installation of 1Generalise with specific Flowline	1Generalise reads data from an Oracle database, which we will populate from an	Proprietary object database technology, however this is transparent to the	The 1Generalise Flowline developed for ELF will be compliant to the ELF specifications, 1Generalise is capable of reading most schemas, currently only from Oracle.	The underlying tools can be configured to work with a range of schemas; 1Generalise will get

Tools	Service providers	Software	Exchange input /output data format	Working data format	ELF compliancy	GML modalities
			ELF GML input. / 1Generalise currently writes data to Oracle, from which it can get translated into various format, including ELF GML.	user.		extended in the next few month to include a wider range of input and output formats.
	Delft University	tGAP builder (prototype implemented in Python)	PostGIS database	Topological data structure / Simple Features	GML/Shapefiles can be converted into PostGIS database	GML can be converted into PostGIS database
	KadasterNL	ESRI ArcGIS	shapefile, geodatabase, SQL database (Oracle, PostgreSQL, etc)	ESRI geodatabase	read ELF data (in flattened relational schemas) directly from other databases, such as PostgreSQL, as well as directly reading common de-facto standard formats such as shapefile	read ELF data GML via the ArcGIS Interoperability Extension.
Transformation	Snowflake	GO Loader and GO Publisher	GML / XML / SQL	N/A	Yes , readable data format are GML / XML / SQL	supported data format are GML / XML / SQL