Updated Guideline for Implementing the ISO 19100 Geographic Information Quality Standards in National Mapping and Cadastral Agencies

EuroGeographics Quality Knowledge Exchange Network

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Introduction

Since the 2007 publication of these Guidelines there has been considerable developments in the Standards relating to Geographic Information.

The ISO 19100 is a series of standards for defining, describing, and managing geographic information, i.e. information concerning objects or phenomena that are directly or indirectly associated with a location relative to the Earth. This series of standards specifies methods, tools and services for management of information, including the definition, acquisition, analysis, access, presentation, and transfer of such data in digital/electronic form between different users, systems and locations.

ISO/TC211 is responsible for the development of international standards in this area of digital Geographic Information. These various standards can be organised into themes for a Geographic Information Technology Framework

Architecture and Framework,

Metadata, Data Content and Definitions,

Core Data Model,

Data Exchange Formats,

Data Interchange and Services,

Data Quality,

Spatial Referencing,

Imagery.

Organisational or managerial quality, at a more general level, is the object of the ISO 9000 family on Quality Management Systems, which is not addressed *per se* in this document. However, we briefly mention some of the new quality related concepts that might be useful in the implementation process that are not currently covered by the ISO 19100 standards (e.g. quality auditing, accreditation, certification).

Several member organizations of the EuroGeographics Quality Knowledge Exchange Network (QKEN) have both expertise in the content of the ISO 19100 standards, and experience regarding their implementation. These updated guidelines provide the most current information for implementing the ISO 19100 data quality standards for national mapping and cadastral authorities (NMCAs).

These guidelines may also be useful for other organizations that produce geographic information, or for users who want to better understand the approaches taken by producers of geographic information, or those who are invited to design specifications in collaboration with producers.

These updated guidelines have been written by a group of experts from England, Sweden, Poland, Lithuania and Ireland. In addition, experts from the entire QKEN have reviewed the content.

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Background

EuroGeographics represents the European National Mapping, Cadastral and Land Registry Authorities. By providing a single point of contact, we enable government, business and citizens to benefit from our collective expertise, products and services.

Our members are the National Mapping, Cadastre & Land Registry Authorities in Europe; they provide a range of products & services and expertise which supports navigation, emergency response, a reliable & secure land and property market and many more government and business decisions and services.

By simplifying access to their data, our members are driving applications to realise social, economic and environmental benefits as well as quicker, more efficient and reliable land registration. Implied in these broad aims and common principles is the idea that enabling data sharing and access has real benefits to both the public sector bodies and the general public. This series of standards specifies methods, tools and services for management of information, including the definition, acquisition, analysis, access, presentation, and transfer of such data in digital/electronic form between different users, systems and locations. A goal of this standardization effort is to facilitate interoperability of geographic information systems, including interoperability in distributed computing environments.

During 2004 the Expert Group on Quality investigated and reported on whether members of the Expert Group were using the following standards:

- ISO 19113 Quality principles
- ISO 19114 Quality evaluation procedures
- ISO 19115 Metadata

The results revealed that just a few countries had implemented the ISO 19100 standards but several countries were planning on implementing them or trying to use part of the standards[1].

Following these results it was decided that the Expert Group on Quality should produce guidelines for using the ISO 19100.

In 2005 the expert group co-operated with EuroSDR and investigated the status of quality specifications, methods and software used in quality assurance. This work was chaired by *Professor Anders Östman*. Their conclusion was that quality elements such as positional accuracy was of major importance, completeness and thematic accuracy of minor importance with lesser interest in timeliness and logical consistency. In general quality management was considered mainly as a cost, not a driving force for change. It was considered important, but its strategic potential was not fully appreciated. The conclusion was that there was a clear need for procedural development in quality assurance which resulted in the original guidelines.

[1] www.eurogeographics.org/eng/documents/Report_ISO_final.doc

In 2011, the now renamed Quality Knowledge Exchange Network (Q-KEN), decided that a follow-up survey on the use of the standards should be conducted. In the intervening period further quality related standards have been released and these are included in this document.

The main objective with the questionnaire was to find out if there has been a change in the use of the quality standards, ISO 19113 Quality principles, 19114 Quality evaluation procedures and 19115 Metadata. A supplementary questionnaire inquiring of the use of the metadata as described in the ISO 19119 Services was sent out later.

The follow up questionnaire included some questions about the use of the guide Guidelines for Implementing the ISO 19100 Geographic Information Quality Standards in National Mapping and Cadastral Authorities and some questions about the new standards in this domain. The questionnaire was sent to all members of Q-KEN representing 26 organisations from 25 countries.

The result this time showed that most of the members are now using the three main data quality standards (ISO 19113, 19114 and 19115) and that the guidelines document produced by EuroGeographics has been used by a number of countries. For the newer standards, their use is less widespread and it is estimated that there are about half of the members using them today. The direct and positive impact of the INSPIRE Directive is illustrated in the result.

Christina Wasström and Gunhild Lönnberg analysed the responses to the questionnaire. The results were presented and discussed at the plenary meeting in May 2011 in Warsaw and a decision was taken to make a report of the result which can be found on the EuroGeographics website.

An additional survey was carried out in 2012 by QKEN and responses were received in 2012 / 2013. The first half of this survey contained the same questions as in the 2005 questionnaire. The second half contained the new questions. These results were reviewed by the QKEN at the Budapest plenary meeting in 2013 and led to a subsequent request for a sub group to update the ISO-19100-Guidelines.

Scope

The scope of this updated guideline is to assist in the implementation of the ISO 19100 data quality standards for geographic information datasets as they relate to the requirements of National Mapping and Cadastral Agencies (NMCAs). The ISO 19100 standards that are discussed from the quality aspect in this guideline are EN ISO 19115 Part 1, ISO 19115 Part 2, TS ISO 19139, ISO 19131 and ISO 19157. It should be noted that this guideline is intended to be used with the actual ISO standards. The guideline describes why it is important to implement the standards and gives practical suggestions on how to read and understand the standards and how to carry out the actual implementation process. It will not discuss policy issues related to implementation of the standards. We also discuss some of the new quality concepts that are not currently covered in the ISO 19100 standard series but might be useful in the implementation process. The guideline is based on the experiences among NMCAs.

Reasons to Implement Quality Standards

National Mapping and Cadastral Authorities (NMCAs) are important players in the development of National Spatial Data Infrastructures (NSDIs). The term Spatial Data Infrastructure has been described in the SDI cookbook[2] as "*the relevant base collection of technologies, policies and institutional arrangements that facilitate the availability of and access to spatial data*." Datasets collected by the NMCAs provide a reference framework for other spatial datasets. It is vital that these data sets have a known quality statement and understanding. The INSPIRE Directive creates a legal framework for the establishment and operation of an SDI in Europe. INSPIRE focuses on environmental policy, but there is an intention to extend it in time to other sectors such as agriculture, transport and energy. It is also intended that the monitoring and improvement of the state of the environment should be implemented. The directive sets requirements for metadata (Article 18) and recognizes spatial data quality as one of the key search criteria. Therefore, NMCAs should have quality information reported in metadata. It is important that the quality information reported is reliable and a method for how this information is gathered is known. By using quality standards NMCAs can ensure this.

In 2006, the ISO TC 211 Working Group on Data Providers conducted a survey to confirm the requirements and current state of standardization.

Most of the respondents (95 %) stated that Geographic Information standards are important. The reasons reported were:

1. Protection of investments
   - data documentation, data quality
   - avoidance of duplication
   - independence from industry standards
2. Improved collaboration
   - Within large organisations with many departments
   - Easier to share, exchange, and integrate data
   - Relationship with client becomes easier
3. Customer requirements
4. Legislative requirement
5. Best practice, learn from others
6. Support of research

The standards that have had a relatively high impact so far (in terms of usage) are the metadata standard and the standards for data content, data definitions and classifications of features. Data quality standards were recognized as important by most of the respondents and there have been many developments in this field

ISO 19157:2013 Geographic information -- Data quality

[2] http://www.gsdi.org/docs2004/Cookbook/cookbookV2.0.pdf

- Establishes the principles for describing the quality of geographic data;
- Defines components for describing data quality;
- Specifies components and content structure of a register for data quality measures;
- Describes general procedures for evaluating the quality of geographic data;
- Establishes principles for reporting data quality.

ISO 19157:2013 also defines a set of data quality measures for use in evaluating and reporting data quality. It is applicable to data producers providing quality information to describe and assess how well a data set conforms to its product specification and to data users attempting to determine whether or not specific geographic data are of sufficient quality for their particular application. However ISO 19157:2013 does not attempt to define minimum acceptable levels of quality for geographic data.

It is foreseen that customer's requirements for knowledge about quality in geographic information will increase. One of the examples of this is the emerging services for ***quality auditing***[3]. Quality auditing can be defined as a systematic method from which one defines, collects and analyses information on a geographic dataset mainly attached to the customer's/user's needs in order to make an objective judgment and/or a decision concerning the use of this data set. Auditing provides a professional independent third-party opinion of the data to the customer. However, it may only be applicable in certain contexts, where users are willing to invest in this service.

Use of geographic information has become more and more web based. Open geospatial standards created possibilities for users to access different geospatial data from different users. There is clearly a need for quality-aware procedures and services. Quality is not only related to data but also to the context in which data is used. The Open Geospatial Consortium (OGC) is an international industry consortium of companies, government agencies and universities participating in a consensus process to develop publicly available interface standards. OGC® Standards support interoperable solutions that "geo-enable" the Web, wireless and location-based services and mainstream IT. The standards empower technology developers to make complex spatial information and services accessible and useful with all kinds of applications. Traditionally mapping agencies have had full control of the process methods and used the same production methods for the whole mapping area. Production of topographic information covered compiling information in the field and/or interpreting aerial photographs. The quality of, for example, topological relationships between objects, was guaranteed by using the same production methods for all feature types in one map sheet. The same production method guaranteed data quality using a "closed" production process. Now, most of the mapping agencies have completed the first digitisation phase of topographic information. Some feature types are collected more frequently than others, which highlight the

[3] See presentation "Auditing Spatial Data Suitability for Specific Applications: Professional and Technological issues at http://www.eurogeographics.org/eng/05_quality_meetings_Feb06.asp

importance of data quality management. This was regarded as a ***new production paradigm***[4] in 2005 and included use of multiple sources in production. It was therefore important to record quality information in the metadata because the quality of features may vary depending on source. Currently many National mapping agencies use other (sub) contractors for producing datasets and it is important to introduce quality management models for controlling their results. ***Quality accreditation***[5] is one approach for this. Quality accreditation is a procedure by which a geographic data producer gives recognition to its suppliers, both external and internal, that they are capable of delivering data to the required quality, on time, in the necessary volumes and at the right cost. Another approach is quality certification, which is a third party attestation, demonstrating that adequate confidence is provided that a duly identified product, process or service is in conformity with a specific standard or other normative document. This new trend of the extensive use of third party data by MNCAs is catered for by ISO/TS 19158:2012.

ISO/TS 19158:2012 Geographic information—Quality assurance of data supply' ISO/TS 19158:2012 provides a framework for quality assurance specific to geographic information. It is based upon the quality principles and quality evaluation procedures of geographic information identified in ISO 19157 and the general quality management principles defined in ISO 9000.

The framework defined in ISO/TS 19158:2012 enables a customer to satisfy itself that its suppliers, both internal and external, are capable of delivering geographic information to the required quality. Fundamental to the framework is the assurance of the supplier's ability to understand and meet the quality requirements. Through the quality assurance framework both the customer and the supplier are able to consider the quality required at the earliest opportunity in the production/update process.

Principles and responsibilities of the relationship between the customer and the supplier that facilitate the framework are provided. The responsibility for the quality assessment procedure is shared between the customer and the supplier.

Other internal needs include:

- Homogeneity in production

  It is important that for example different production units produce uniform quality or different regions have uniform quality.

- Homogeneity in diffusion

  Customers expect that quality is as specified and diffusion process is part of the total process.

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[4] See doctoral dissertation of Jakobsson http://lib.tkk.fi/Diss/2006/isbn9512282062/

[5] See presentation “Quality accreditation “A Journey Towards Perfection” at http://www.eurogeographics.org/eng/05_quality_meetings_Feb06.asp

- Homogeneity in automation of working flows
- Possible opportunity for restructuring processes
- Motivation of personnel

We have here covered some of the reasons to implement quality standards for a national mapping agency. *Figure 1* illustrates the reasons presented. We can categorize reasons as legislative, technological, production and markets.

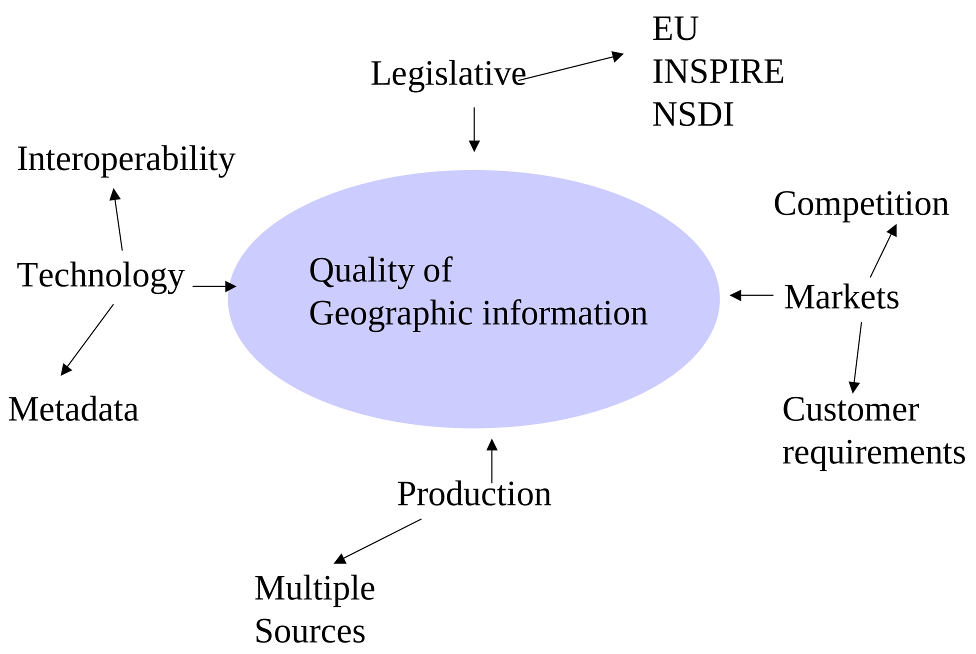

Figure 1 Reasons for Implementing Quality Standards

Abbreviations and Definitions

AAA	AFIS-ALKIS-ATKIS (ISO based data model for geodetic, real estate and topographic data in Germany)
Accreditation	Procedure by which an authoritative body gives formal recognition that a body or person is competent to carry out specific tasks.
AFIS	Amtliches Festpunktinformationssystem (Authoritative Geodetic Control Station Information System in Germany)
ALB	Automatisiertes Liegenschaftsbuch (Automated Real Estate Register in Germany)
ALK	Automatisierte Liegenschaftskarte (Automated Real Estate Map in Germany)
ALKIS	Amtliches Liegenschaftskatasterinformationssystem (Authoritative Real Estate Cadastre Information System in Germany)
AQL	Acceptable Quality Level, also Acceptance Quality Limit
ATKIS	Amtliches Topographisch-Kartographisches Informationssystem (Authoritative Topographic Data System in Germany)
ATS	Abstract Test Suites
BKG	Bundesamt für Kartographie and Geodäsie (Federal Agency for Cartography and Geodesy)
CEN	European Committee for Standardization
Certification	Action by a third party, demonstrating that adequate confidence is provided that a duly identified product, process or service is in conformity with a specific standard or other normative document
Conformance quality level	Threshold value or set of threshold values for data quality results used to determine how well a dataset meets the criteria set forth in its product specification or user requirements
Conformance quality requirements	Quality requirements derived from user requirements that state the conformance quality levels
DLM	Digitales Landschaftsmodell (Digital Landscape Model in Germany)
DIN	Deutsches Institut für Normung e.V. (German standardization organisation)
DQL	Declared Quality Level
EBM	EuroBoundaries
ELF	European Location Framework
ELS	European Location Services
ESDIN	European Spatial Data Infrastructure Network
ETS	Executable Test Suite
EuroRoadS	A pan-European Road Data Solution
EuroSDR	Spatial Data Research Organization (http://www.eurosdr.net/)
Feature	abstraction of real world phenomena
Feature type	class of real world phenomena with common properties
FGDP	Focus group on data providers (www.isotc211fgdp.info)
GDZ	Geodatenzentrum (geodata centre, branch office of BKG)
GFM	General Feature Model

GML	Geography Markup Language
IGN	Institut Géographique National (National Geographic Institute of France)
JUHTA	Julkisen hallinnon tietohallinnon neuvottelukunta (Advisory Committee for Information Management in Public Administration)
Harmonisation	Integrates schemas or feature types with a new integrated schema
INSPIRE	Directive for European Spatial Infrastructure
Interoperability	The possibility for spatial datasets to be combined, and for services to interact, without repetitive manual intervention, in such a way that the result is coherent and the added value of the data sets and services is enhanced
ISO	International Organization for Standardization
ISO 9000	Quality management standard series
ISO TC 211	Technical Committee in charge of ISO 19100 series in the International Organization for Standardization
KMS	Kort & Matrkelstyrelsen
LVA	Landesvermessungsamt (surveying and mapping authority of a German state)
Metadata	Data about data
Multiple representation database	consisting of datasets, in which those objects that represent the same physical entities are connected
NAS	Normbasierte Austauschschnittstelle (Standards-based data exchange interface, part of AAA-concept in Germany)
NMCA	National Mapping and Cadastre Agency
NSDI	National Spatial Data Infrastructure
OGC	Open Geospatial Consortium
ontology	The result of making explicit the agreement within communities
QE	Quality Evaluation
QFD	Quality Function Deployment
QM	Quality Management
QMS	Quality Management System
Quality	fitness for use, including both quality of design, conformance to the design (production oriented quality), customer satisfaction and the needs of society or environment
Quality accreditation	Procedure by which a geographic data producer gives recognition to its suppliers, both external and internal, that they are capable of delivering data to the required quality, on time, in the necessary volumes and at the right cost.
Quality assurance	All quality related activities, in the overall process, that ensure the quality in the service or product for the end user.
Quality auditing	A systematic method from which one defines, collects and analyses information on a geographic dataset mainly attached to the customer's/user's needs in order to make an objective judgement and or a decision concerning the use of this dataset.
Quality control	Testing against the specification and taking actions to remedy any problems identified.
Quality evaluation	Testing against the specification in order to report quality results
Quality management	Coordinated activities to direct and control an organization with regard to quality
Quality model	A quality model is a framework for measuring and presenting the quality of a spatial dataset. It contains a number of distinct parts some of which may not be applicable to some datasets. These are:

- An assessment of the quality requirements of the dataset usually expressed in terms of quality elements as defined in ISO 19157.

- The identification of the evaluation methods, usually defined in terms of ISO 19157

- The identification of the metadata recording process defined as described in ISO 19115-I or in a quality report.

In addition to this the model may include the following:

- Details of any additional methods used to control quality in the production flowline such as (but not limited to) validation tools, quality control, quality assurance or accreditation

- Details of any post flowline testing

- The required quality levels

Quality reference datasets	Datasets reputed to be of very good quality used for comparison when the quality of other datasets has to be measured.
Reference datasets	Series of datasets that everyone involved with geographic information uses to reference his/her own data as part of their work. They provide a common link between applications and thereby provide a mechanism for the sharing of knowledge and information amongst people
RMSE	Root mean square error
Schema integration	The establishment a formal relationship between two schemas using expert knowledge
Semantics	The relationship between the computer representations and the corresponding real world feature within a certain context
SDI	Spatial Data Infrastructure
Universe of discourse	View of the real or hypothetical world that includes everything of interest
Usability	The measure of a product's potential to accomplish the goals of the user
UML	Unified Modelling Language
WFS	Web Feature Service
WMS	Web Map Service
XML	Extensible Markup Language
XSD	XML-Schema-Definition

Reading Guide

This document is aimed at technically experienced people with some knowledge about quality and quality evaluation of geographic information at the NMCAs. If you are a manager that is looking to identify how your organization should start implementing the ISO 19100 quality standards we recommend that you read the introduction, then Chapters 3 and 4 followed by Chapter 2. If you are not familiar with the quality concepts then we recommend that you start with Chapters 1 and 2. We recommend that you also read some general books about quality.

The first Chapter focuses on the **interpretation of quality concepts** in reference data sets. It discusses the differences between cadastral data sets and topographic data sets.

Chapter 2 provides a brief **description of the most important standards** in the ISO 19100 series of quality standards. It also gives an overview of the current status of the standards. It should be used in connection with the standard text.

Chapter 3 gives **implementation guidance**. It introduces some overall information about how to describe and how to find your needs before implementing the standards. It also gives you information on how to address those needs using the standards and gives you suggestions on where to start. The chapter also gives information on how to implement common quality phenomenon using the standards.

Chapter 4 discusses different **strategies for implementing the standards**.

Chapter 5, we give some indication on where good practices and further advice may be found.

1. Interpretation of the quality concept in reference data sets

1.1. Introduction

Quality can have different interpretations depending on where in the production and usage life cycle the reference data is. *Table 1* and *Figure 2* illustrate three different phases of a reference data set (before production, production and after production, documentation of quality, goal for quality, quality methods and level). The ISO 19100 quality standards can be used in this process to specify and report data quality. Chapter 3 and *Table 12* give more guidance on this.

Table 1 Interpretation of Quality in Different Phases of Production

Phase	Quality documentation	Goal for quality	Quality methods	Level
Before production	Specification -> quality model	Define quality requirements	Investigation of customer requirements	Feature type level
Production	Database->Process history	Meet the specification Record expected quality to database	Inspection	Feature instance (e.g. dates, positional accuracy)
After production	Metadata Test reports	Measure conformance to quality requirements	Evaluation Reporting	Dataset level

Before production it is important to specify quality requirements for data sets. This can be done by describing a ***quality model.*** In the quality model, quality elements should be specified including goals for quality (***conformance quality)*** at feature type level. ISO 19100 series does not specify the content of a quality model but the same principles can be used to organize the content of a quality model. A good example of a quality model on the international level has been developed by European NMCAs during the ESDIN project[6]. Definition of a quality model is important for large reference data sets in order to report quality in metadata. Quality evaluation results will only confirm that quality requirements are met. After an update in the database, evaluation results are no longer

[6] See documents in the section Metadata and Quality Guidelines on http://www.esdin.eu/project/summary-esdin-project-public-deliverables

valid and therefore metadata of large reference data sets contain conformance quality levels and information about performed tests. Quality requirements should be investigated by utilizing user requirement studies.

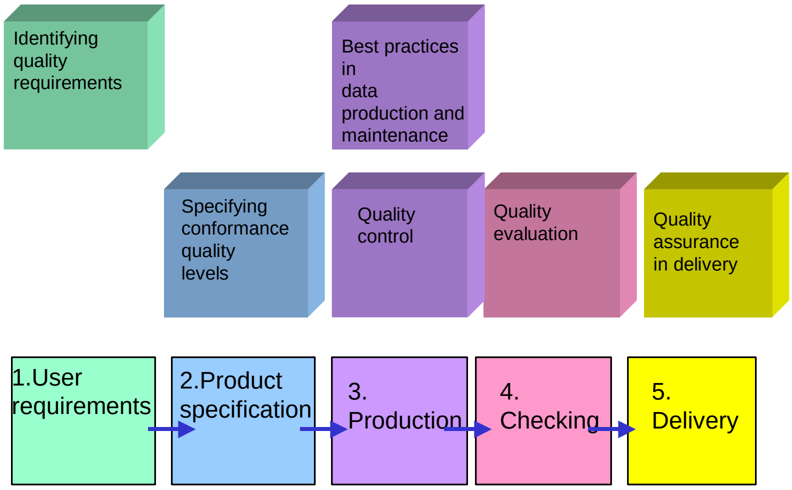

Figure 2 Quality in General Production Process

During production **quality management principles** should be applied according to the ISO 19157 standard. Recommended methods include introducing a process management and ISO 9000 principles[7]. Organizations may also ***certificate*** quality management processes. During the production process, history should be recorded as ***lineage (including dates).*** It should be done utilising ISO 19115-1 Metadata standard. The database may contain expected quality measures based on production methods (e.g. positional accuracy) at feature instance level.

After production **quality evaluation** should be performed and ***metadata*** should be finalized. Quality evaluation should be made according to ISO 19157 standard. There are different strategies for how a quality evaluation may be performed. In order to analyse the reliability of a certain process, e.g. an information process, a reliability analysis might be performed. An example of such analysis can be found from EuroRoadS project[8].

[7] See Quality Management Guideline of the Expert Group on Quality

[8] See document D2.3 Probabilistic model to describe and evaluate information quality. http://www.euroroads.org/php/Reports/D2.3.pdf. It should be noted that this procedure is applicable only to a situation where reliability of a certain process is the main concern.

In some cases there may be a need for additional verification of product quality as delivered by external data supplier. This quality may be achieved by implementing quality assurance as a part of quality management process. Quality assurance should be made according to ISO 19158 standard

1.2. Cadastral Issues

This chapter will introduce some quality issues related to cadastre. It is not meant to include a comprehensive list of quality issues. Legal status in countries may also vary so that the discussion here may not be applicable to all national cadastral data sets.

The interest of users may be different when compared with topographical data users. Users of cadastral information are interested in both the legal and spatial part of the information. However the legal part is mostly dominating.

European cadastre's can be categorized as

- Positionally-accurate cadastre

  In positionally-accurate type cadastres the attribute (ownership records) and the location are both up-to-date and accurate. These can be found in Austria, the Netherlands and Finland (urban areas).

- Index map cadastre

  In index map type cadastres, the actual representation of the property units can be found either from legal documents or in the field but the ownership records are accurate and up-to-date. Index maps present the topological relations between the cadastral units. Examples of these cadastres can be found in Sweden and Finland (outside urban areas).

- Mosaic cadastre

  In mosaic type cadastres there in no legal requirement to register the ownership and therefore the cadastre often covers only part of the country. The Cadastre contains information of individual ownerships, but there is no direct relationship with neighbouring parcels. Combinations of different title maps may be compiled or reproduced but the topological relations remain undefined. These cadastres exist in Great Britain, United States and Canada.

Table 2 depicts the categorization of different cadastral types and how quality is improved. Also the role of quality is different in each type. In positionally-accurate cadastre the quality management process is very important so that the information is not accidentally changed in the process steps.

In the real world physical features such as fences, hedges or the side of a building usually mark the ownership. The quality aspect of this is that the features must be kept in their correct location.

Table 2 Different Types of Cadastres and the Role of Quality

Cadastre Type	Ownership data	Location data	Potential quality issues
Mosaic	Ownership records	Ownership maps (general boundaries)	Reliability No other quality information available
Index	Ownership as attribute information	Uniform index map	Positional Accuracy Topological consistency Process management
Positionally-accurate	Ownership as attribute information	Accurate location of boundary points	Logical consistency Security issues Process management

In Finland and Sweden the National Land Surveys manage the land surveying process and the cadastre. Whilst, for example, in Denmark private surveyors have the responsibility of land surveying. In principle this should have no effect on how quality is managed but in practice there are differences in how organisations implement the process management. Traditionally organisations have not paid so much interest to contractor's processes and only checked that the results are correct. This may have led to some duplication and extra costs in the process. Also responsibility for quality might be different. In Finland and Sweden the National Land Survey has the responsibility for the quality concerning land survey results whilst in Denmark the surveyors have this responsibility.

Most cadastral data sets have a large variation in absolute and relative positional accuracy. The absolute accuracy of the neighbouring boundary points can vary between 10 cm to several metres, while relative accuracy of the neighbouring parcels is well defined. This means that it can be very difficult to make test procedures with a common conformance level for the whole data set. Instead new measured points can have a different conformance level compared with the average situation.

Lineage and historical data in cadastral data sets is very important. It is very important that you can go back and see what the cadastral situation was at any given point in time. It's part of the legislation for the cadastral data sets, that you are able to document the current situation at a given time.

Metadata for cadastral data is also a challenge, for two reasons:

1. The update frequency is continuous; this means that the metadata production should be integrated with the continuous update process.
2. The data quality will be improved/changed every day. Quality evaluation results are therefore not valid for a long period of time. Metadata should therefore contain quality information about conformance quality levels together with recorded quality measures from the database (e.g. expected mean values of positional uncertainties 0.1m and 0.2 m).

The most important quality elements are as follows:

- Positional accuracy is important from the legal aspect. It is important that cadastral information has sufficient accuracy because it is important to know rather exactly the right owner e.g. when cadastral information is combined with different datasets. Estimation of positional accuracy is important because of the continuous change of features, adaptation of old information and new information.
- Lineage information is important because an estimate of the positional accuracy can be derived from the source and production method.
- Thematic accuracy
- Completeness.
- Logical consistency
- Temporal validity

There is a need to report data quality at dataset and feature/instance levels. There is also a need to integrate new measurements to the existing data. Therefore it is important to know the estimated quality at the instance level.

Sampling may be used to check the quality when registering the cadastral updates.

1.3. Topographic issues

The most common way of updating topographic features is through a periodic updating cycle. Generally speaking it is a full update, which means that all topographic items belonging to a dataset are updated at the same time (while the features in the dataset may have been surveyed or captured at different times). However certain customers are more interested in theme based or particular features such as buildings. Rather than periodic updates there is an increasing expectation that such features will be captured within a specified time following completion. We notice that customers are more and more interested in the currency of the topographic information. This leads to ways of continuous updating whereby customer needs are or should be leading to prioritisation of issues for continuous updating.

We frequently see a need for continuous updating in infrastructural features e.g. roads, railways, power lines and buildings. The problem is how to incorporate these items in existing datasets. Addition of new items is not the real problem; the real problem is it invariably leads to changes (updates) to items, which are not specified for continuous updating. For example, when roads are included in the continuous update plan and there is a change in that feature. Invariably the fields surrounding the road have to be changed as well (and possibly the unique identifiers).

The easiest way is by providing enough capacity to do a full continuous update. The other way is to create an object oriented database with unique identification codes for each topographic object/issue. Here the objects/issues exist in themselves and in object attributes you can show the update time and the temporality of the object.

Quality evaluation according to the ISO 19100 series provides the possibility to add quality aspects to each object in the database. Setting up the specifications for the different topographic objects or issues according to ISO 19100 provides a platform for evaluating quality. For each feature type conformance levels should be defined according to Table 2.1. “Quality elements in the ISO 19157 standard” giving a good start for evaluating quality.

Changing to continuous updating brings the need to co-operate with others who also produce topographic information. It is important and often difficult to gather information from others using the right unique identification codes. A universal identification code system for a country could be a solution. Moreover, such system should be conformant with international system established in international initiatives. An example of such an initiative is INSPIRE. INSPIRE strongly recommends providing unique identifiers for spatial object types where references from other spatial objects are expected to be applicable[9]. An intermediate solution might be to allocate your own unique identification codes for this information. However, setting up comprehensive unique identifiers system is a difficult task that requires careful planning and cooperation with national and often international interested parties.

More difficult is the communication problem, especially communication about the specifications. What is provided by the co-operating company and in what way the information reaches the database specifications. There must be good agreement between the companies. INSPIRE provides a framework for dealing with such issues on national and European level[10][11].

Providing clear specifications and quality items for the objects/issues can solve the quality management problem arising from using information from co-operating companies. The NMCAs should develop a way to evaluate the quality of the information from the co-operating companies in the same way they evaluate the quality of their own database. ISO 19158 Quality Assurance of Data Supply may be used to perform this task.

The problem in updating can be divided in two questions:

- Are customers’ needs for updating features consistent? Customer needs must be the input for continuous updating; do they require full or partly continuous updating?

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[9] See document INSPIRE Generic Conceptual Model http://inspire.ec.europa.eu/index.cfm/pageid/2

[10] See document Drafting Team "Data Specifications" Methodology for the development of data specifications http://inspire.ec.europa.eu/index.cfm/pageid/2/list/2

[11] See document A Conceptual Model for Developing Interoperability Specifications in Spatial Data Infrastructures, 2012 http://inspire.jrc.ec.europa.eu/documents/Data_Specifications/IES_Spatial_Data_Infrastructures_(online).pdf

- Is it possible to get all information from different co-operating companies at the right time and in the same specifications and quality? It is important to investigate if the effort in getting information from co-operating companies is less expensive than getting the information by yourself. Task of verification the quality of data provided by co-operating company can by to some extend automated by utilising rules based applications which are available on the market and which can be customised to particular data specifications and user requirements. Thus, significantly lowering the cost required for data quality inspection. Also the logistics of getting the information from others is important, how true are co-operating companies in updating the information, is it possible to have influence on the their updating cycle? And, as mentioned before, how is to be assured that the quality of the information matches the specifications.

The interoperability problem exists when you start getting data from other providers. It can be solved in several ways:

- Ontology-matching, data-matching

Cope with the different specifications from the co-operating companies and transfer the objects/features into your own specifications using ontology. It is applicable in some cases but you might end-up in gathering information again.

- Data harmonization effort:

  Put a lot of effort in communication about specifications and try to reach with all co-operating companies the same specifications, at least at the time they deliver the information.

  Put effort into creating a law or mandatory requirement for standardization of topographic information that must be used in all national processes, developments and planning of the national topographic landscape.

In general, quality evaluation of the master database is important (most important may be the logical consistency). If you don’t know the quality of a master database it is very difficult or impossible to evaluate the quality of a derived database. Quality of a derived database is dependent on quality of a master database. ISO 19157 can be used to evaluate the master database (original observation) data when completing further processing (i.e. generalization). Quality evaluation of derived datasets can consist of logical consistency checks that can be automated and based on generalization rules. If the quality of a master database has been evaluated then quality of a derived database is mostly dependent on generalization rules.

The management of object history (e.g. by using ids, time stamps and linking the current and history records) which enables the retrieval of change information (new, altered and deleted objects during a given period of time) is essential for in-house as well as possible customer needs.[12]

For European co-operation and interoperability, NMCAs should start by describing ‘minimum’ specifications for topographic features. In general “minimum” specifications are specifications containing features and its attributes that can be provided by most (ideally by all) of NMCAs. The INSPIRE process together with EuroGeographics projects (EuroSpec, EuroRoadS, EuroBoundaries, EuroGlobalMap, EuroRegionalMap, ESDIN, ELF and European Location Framework) have already started this process. These specifications are based on the ISO 19131 standard Data Product Specifications

Handling of multi-source, multi-accuracy, multi-scale topographic information can be achieved using attributed information at a topographic feature level. This can be implemented by multi-resolution databases. Quality information should also cover attribute information, not only the feature type information.

[12] See Benchmarking report on generalization, Expert Group on Quality, 2005 http://www.eurogeographics.org/eng/documents/Benchmarking_FR-2004_ver_09.doc

2. The ISO 19100 Quality Standards

2.1. Brief Introduction to the Quality Related Standards

One of the most important goals for the ISO 19100 series of standards is to enable geospatial datasets to interact between different data models and different applications. The more geospatial datasets that exist with different data models and different levels of quality the more important it is that the user is aware of where and how the datasets can be used in an application.

The Quality-related standards in the ISO 19100 family are:

- EN ISO 19115-1 Geographic Information – Metadata – Part 1: Fundamentals
- EN ISO 19115-2 Geographic Information – Metadata – Part 2 : Extensions for imagery and gridded data
- ISO 19115-3 Geographic information - Metadata - Part 3: Metadata
- EN ISO/TS 19139 Geographic Information – Metadata – XML implementation
- EN ISO 19131 Geographic Information – Data product specifications
- EN ISO 19157 Geographic Information – Data quality
- ISO 19157 Geographic Information – Data quality - Part 2: XML schema implementation
- ISO/TS 19158 Geographic Information - Quality assurance of data supply

Note 1: This Guideline will not discuss the specific aspects of the quality of imagery data, to which, of course, the general concepts and principles apply.

2.2. EN ISO 19115-1 Geographic Information – Metadata – Part 1: Fundamentals

2.2.1. Current status of the standard

ISO 19115 was first published in 2003 and CEN has published it as a European standard in January 2005. A technical corrigendum was published in 2006. A new version of the standard is published in 2014 as ISO 19115-1 (*Fundamentals*).

ISO 19115-2 Metadata part 2 – Extensions for imagery and gridded data, was published in 2009.

2.2.2. Description of content

This international standard defines general-purpose metadata for digital geographic data and provides a structure for describing all metadata given in the ISO 19100 standards. More detailed metadata for geographic data types and services are defined in other ISO 19100 standards and user extensions. For the *Data quality* (ISO 19157) the UML schema and data dictionary for documenting is a part of this document.

To make all the data included in metadata easier to overview and handle, the data is structured in groups. In UML a group is called a package. The names of the packages that include the data quality information elements are *Lineage information* and *Identification information*. The uniting entity is the UML class *MD_Metadata*.

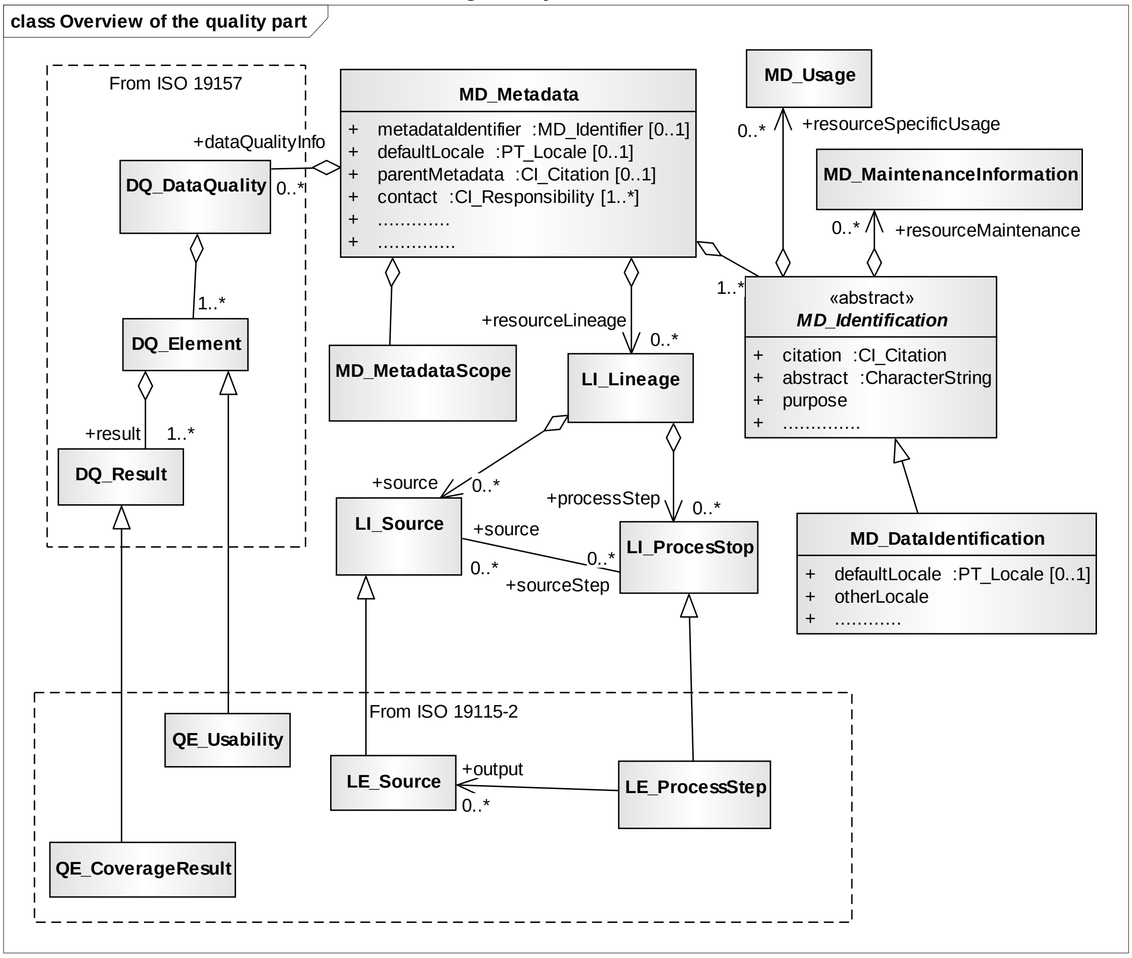

Figure 3 Quality Package in Metadata

The data quality elements were moved in this revision to ISO 19157.The data quality overview elements are documented in the *Identification information* and *Lineage* *information* packages and in class *MD_MetadataScope*. Purpose and usage is included in *Identification information* and *Lineage information.*

Table 3 Where to Document the Quality Elements in Metadata

Quality element		Package	Class	Attribute
scope			MD_MetadataScope	resourceScope
scope		Identification information	MD_Identyfication	extent
purpose		Identification information	MD_Identyfication	purpose
usage		Identification information	MD_Usage	specificUsage usageDateTime userDeterminedLimitations userContactInfo response additionalDocumentation identifiedIssues
lineage	history	Lineage information	LI_Lineage	statement
	process step	Lineage information	LI_ProcessStep	description rationale stepDateTime processor reference scope
	source information	Data Quality information	LI_Source	description sourceSpatialResolution sourceReferenceSystem sourceCitation sourceMetadata scope
	Scope	Lineage information	LI_Lineage	scope
	maintenance	Identification information	MD_MaintenanceInformation	maintenanceAndUpdateFrequency maintenanceDate userDefinedMaintenanceFrequency maintenanceScope maintenanceNote contact

The data quality elements are excluded in *Table 3* because they Has been moved to ISO 19157 Data quality.

The UML diagrams are found in Clause 6 of part 1 of the standard and in Annex A in part 2 of the standard and the data dictionaries are found in Annex B in part 1 and in part 2 of the standard. In this text there is a reference to the data dictionary for each data quality element.

2.2.3. Scope

To document the quality for a dataset, you may have to use one or more metadata entities. A data quality scope may be a dataset series to which a dataset belongs, the dataset or a smaller grouping of data located physically within a dataset sharing common characteristics. The metadata model is structured in a way that makes it possible to handle this.

The scope for a metadata entity is defined by *MD_MetadataScope* which is part of *MD_Metadata* and *extent* in *MD_Identification*, and this is also the scope for the data quality overview elements. In *resourceScope* of *MD_MetadataScope* the type of data is recorded and in *extent* the spatial and temporal extent is stored. Metadata that is common for several datasets is given in one metadata entity with its *resourceScope*. Then, more specific data is documented in each individual entity and a reference to the more general entity is used, with help from the attribute *parentMetadata* and only data that is different has to be included. All common data is specified in the more general entity.

The scope for the data quality overview elements is the same as for the metadata entity, the only difference being for lineage. Lineage should be specified for the series or dataset and also, if needed, for smaller groupings of data. For this reason, lineage is documented on its own and uses the class *MD_Scope* to specify the scope of the distinguished group. It is possible to document lineage for as many groupings of data as necessary for each metadata entity. The maintenance part of lineage is not included here; it is documented in *Identification information,* and has its own declaration of scope.

The data dictionary for *MD_ScopeCode* is located in section *B.2.1.* For *resourceLevel* there is a list of permitted values documented in *MD_ScopeCode,* located in section *B.3.28 MD_ScopeCode <<CodeList>>.* The data dictionary for the class *MD_Metadata* is located in section *B.2 Metadata entity set information* and for the spatial and temporal extent *EX_Extent* in section *B.15 Extent information*.

Table 4 Metadata Elements Needed to Document the Scope

Name	Definition	Data type/Domain	Example
MD_Metadata	Root entity which defines metadata about a resource or resources	Class	
metadataIdentifier	Unique identifier for this metadata record	MD_Identifier	
parentMetadata	identifier of the parent metadata record	CI_Citation	
MD_MetadataScope	Information about the scope of the resource	Class	
metadataScope	code for the scope	MD_ScopeCode attribute attributeType collectionHardware collectionSession dataset series nonGeographicDataset dimensionGroup feature featureType propertyType fieldSession software service model tile	dataset
name	description of the scope	CharacterString	Transport

MD_Identification	Basic information required to uniquely identify a resource or resources	Class	
Extent	Spatial and temporal extent of the resource	EX_Extent	Sweden
MD_Scope	The target resource and physical extent for which information is reported	Class	
Level	target resource covered	MD_ScopeCode	attributeType
Extent	Information about the horizontal, vertical and temporal extent of the resource specified by the scope	EX_Extent	Sweden Anm:As it is the same as in MD_Identification, it could be omitted
LevelDescription	detailed (listing of the items specified by the level)	MD_ScopeDescription Description of the class of information covered by the information	roads

2.2.4. Data quality overview elements

The elements purpose, their usage and the maintenance part of lineage are documented, together with metadata, for data and service identification. The description is found in section *B.3 Identification information*. For purpose and usage the scope is documented by the *MD_Metadata* entity and it is used to give maintenance for the entire dataset. For the parts of the dataset with different maintenance, it is possible to document one entity for each group as needed, each with its own scope.

The purpose is defined as an attribute type in the identification part and is documented as text. The description is found in section *B.3 Identification information.*

Usage and Maintenance are documented as classes that can be recorded a number of times. The descriptions are found in sections *B.3.5 Usage information and B.6 Maintenance information.*

Part 2 of the standard – ISO 19115-2 defines the subclass: *DQ_Element* – *QE_Usability*. This data quality measure differs from those specified in part 1 of the standard and provides user-specific quality information about the suitability of a dataset for a particular application. The description is found in section *B.2.2.3*.

Lineage is documented without the data quality elements, *which have been moved to ISO 19157*. Its description is found in section *B.5 Lineage information.* Lineage should describe the history of a dataset and is documented as text with its own scope and the classes LI_Source and LI_ProcessStep. The description is found in section *B.5 Lineage information.* As a minimum, a general explanation of the data producer's knowledge about the lineage of a dataset should be given as text in the attribute type *statement* or in one of the classes: *LI_Source* and *LI_ProcessStep*, and it is possible to document lineage for as many smaller groupings of data as is necessary.

2.2.5. Data quality elements

The data quality elements were moved in this revision to ISO 19157.

2.2.6. Usage

The standard shall be used to document the quality requirement and lineage for a dataset and the quality results for the quality evaluation using ISO 19157. The metadata can then be used to discover, retrieve and reuse datasets.

2.3. EN ISO 19115-2 Geographic Information – Metadata – Part 2 : Extensions for imagery and gridded data

2.3.1. Current status

The ISO 19115-2 standard was published in 2009. A revision started in 2015.

2.3.2. Description of content

Part 2 of the metadata standard extends Metadata:2005 with metadata needed to document information about imagery and gridded data.

In the data quality part of the standard subclasses to the classes DQ_Result and LI_ProcessStep are defined and an extension to describe the quality of ground control points is included.

2.4. ISO 19115-3 Geographic Information – Metadata – Part 3: XML schema implementation of metadata fundamentals

2.4.1. Current status

Part 3 is under development.

2.4.2. Description of content

This technical specification defines eXtensible Markup Language (XML) schemas for encoding 19115-1 metadata content.

2.5. EN ISO 19131 Geographic information — Data product specifications

2.5.1. Current status

ISO 19131 standard was published in 2007. A technical corrigendum was published in 2008. A revision started in 2016.

2.5.2. Description of content

The purpose of ISO19131 is to help creators of GI product specifications to structure their documents in a way that is consistent with the other standards of the Geographic Information family. Product specifications are reference documents that state what kinds of geographical phenomena are intended to be covered by the dataset, and how these phenomena are represented. From a quality perspective, specifications play a key role in conveying to all users the universe of discourse that presided to the constitution of the geographical product (See Fig. 2.1). In addition, and more specifically, the specification of how far the data in the product is permitted to depart from the universe of discourse (in other words, the data quality elements and their usual measures).

ISO 19131 lists the major sections of a product specification:

- Overview of the product (informal description of the product, extent, purpose, data sources and production and maintenance processes...)
- Specification scopes (explaining to what spatial or hierarchical or functional subpart of a more general product the present specifications apply)
- Data product identification (name of product, abstract, category, geographic description, purpose, type of spatial representation, scale or resolution...)
- Data content and structure (application schema and feature catalogue for vector data, description of how ”coverage” works for raster, image, terrain models etc.)
- Reference systems (temporal and spatial – e.g. a coordinate reference system or a system using geographic identifiers)
- Data Quality (what is assessed; how it is assessed and what the results are: in conformance with ISO 19157)
- Data capture (not mandatory; indication of sources, quality controls...)
- Data maintenance (not mandatory; indication of how data are maintained, frequency of integration of changes and additions...)
- Portrayal (not mandatory; indication on how the data are best visually displayed...)
- Data product delivery (delivery format, delivery medium),
- Additional information (not mandatory)
- Metadata (the core metadata elements of ISO19115:2005)

2.5.3. Usage

ISO 19131 may be used by producers when they want to write product specifications in consistency with other ISO 19100 standards.

As a checklist of the important issues that must not be forgotten, the ISO 19131 standard may also prove helpful when specifications are established, even if one does not intend to make them formally compliant to the ISO standard.

ISO 19131 may also be used by users when they want to understand, or when they're asked to contribute to, ISO19131-compliant product specifications, or more generally, when they wonder what specifications are for geographical products. The data specifications produced in the INSPIRE and ELF projects are examples of the use.

2.6. ISO/TS 19139 Geographic Information - Metadata – XML schema Implementation Specification

2.6.1. Current status of the technical specification (TS)

ISO/TS 19139 was published in 2007. A revision is planned to be available from the middle of 2017. The parts that describes metadata and quality is moved to own parts of ISO 19115 part 3 and ISO 19157 part 2.

2.6.2. Description of content

ISO 19115-1 provides a universal, encoding-independent view of metadata for geographic data expressed in UML. Quality data as a part of geographic metadata is represented in ISO 19115-1 as a set of UML packages. To prevent all users of geographic metadata from using their own version when implementing the standard, this technical specification provides a universal implementation of ISO 19115-1 and a XML(eXtensible Markup Language) schema that conforms to the rules described in ISO 19118, Geographic information - Encoding.

For all packages in ISO 19115 there is an XML schema file with the same name as the package, as an example dataQuality.xsd contains the implementation of the Data quality information package. The XML schemas associated with each of these namespaces is found at http://www.isotc211.org/schemas/2005/gmd .

2.7. EN ISO 19157 Geographic Information – Data quality

2.7.1. Current status of the standard

ISO 19157 was published in 2013 and replaces ISO 19113, 19114 and 19138 and CEN has published it as a European standard.

2.7.2. Description of content

The purpose of EN ISO 19157 is to:

- Establish principles for describing the quality of geographic data
- Specify components for reporting quality
- Organize information about data quality

It is applicable both to data producers and users.

Figure 4 provides an overview of data quality information.

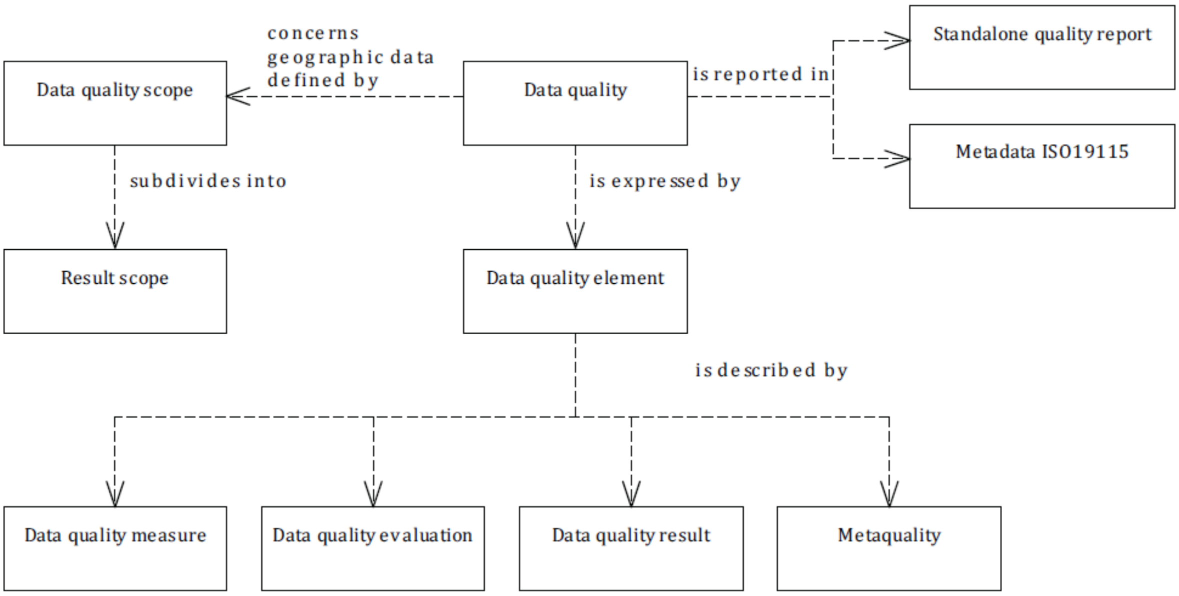

Figure 4 Conceptual model of quality for geographic data

Figure 5 represents the concept of data quality that is used in the standard. Data quality is a difference between universe of discourse, (i.e. a view on the real or hypothetical world), which is defined by a product specification, and a dataset. A data producer's view on data quality and the users' view on data quality may merge if the requirements are identical.

Data quality is the difference between a dataset and a universe of discourse. Producers and users may use different universes of discourse, and will thus assess differently the quality of the same dataset. The role of product specifications (if possible, including *a priori* known user requirements) in establishing a generic, or clearly structured, universe of discourse, is central and the subject of the ISO 19131 standard.

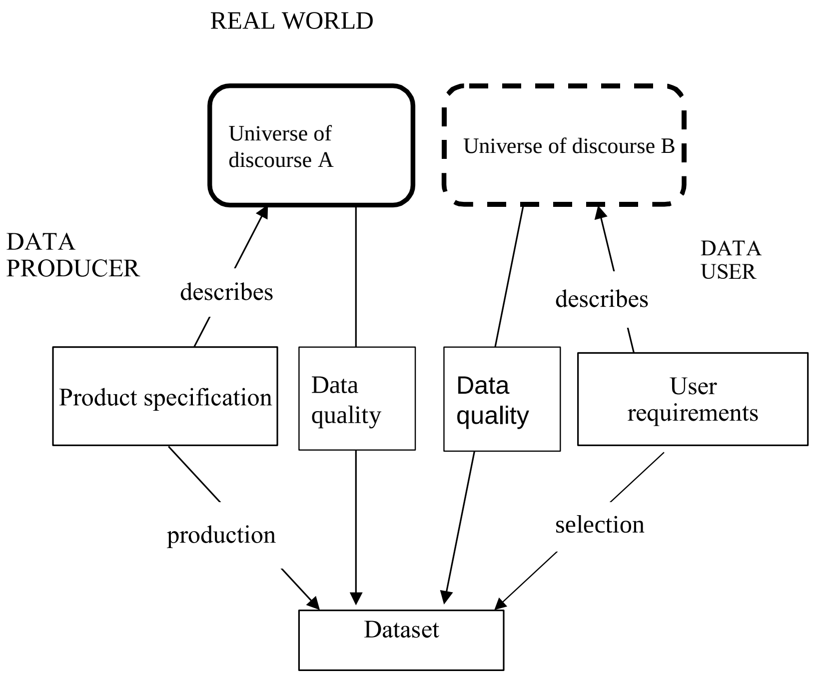

Figure 5 Concept of Data Quality

The ISO 19157 standard does not specify how to measure the differences between a dataset and universe of discourse. It defines taxonomy of the various kinds of differences that are usually measured, those various kinds of differences being called data quality elements. It also describes how to identify whether these elements apply to one given dataset and how the reporting of quality assessment should be performed. A data quality element is a component describing a certain aspect of the quality of geographic data. These have been organized into different categories

Table 5 describes the data quality elements that are defined in the standard.

Table 5 Data quality categories and elements in the ISO 19157 Standard

Category Data quality element	**Description**
Completeness	Presence or absence of features, their attributes and relationships
Commission	Excess data present in a dataset
Omission	Data absent from a dataset

Category	**Description**
Data quality element	
Logical consistency	Degree of adherence to logical rules of data structure, attribution and relationships
Conceptual consistency	Adherence to rules of the conceptual schema
Domain consistency	Adherence of values to the value domains
Format consistency	Degree to which data is stored in accordance with the physical structure of the data set
Topological consistency	Correctness of the explicitly encoded topological characteristics of a dataset
Positional accuracy	Accuracy of the position of features
Absolute or external accuracy	Closeness of reported coordinate values to values accepted as or being true
Relative or internal accuracy	Closeness of the relative positions of features in a dataset to their respective relative positions accepted as or being true
Gridded data position accuracy	Closeness of gridded data position values to values accepted as or being true
Temporal accuracy	Accuracy of the temporal attributes and temporal relationships of features
Accuracy of a time measurement	Correctness of the temporal references of an item (reporting of error in time measurement)
Temporal consistency	Correctness of ordered events or sequences, if reported
Temporal validity	Validity of data with respect to time
Thematic accuracy	Accuracy of quantitative attributes and the correctness of non-quantitative attributes and of the classifications of features and their relationships
Classification correctness	Comparison of the classes assigned to features or their attributes to a universe of discourse (e.g. ground truth or reference data set)
Non-quantitative attribute correctness	Correctness of non-quantitative attributes
Quantitative attribute accuracy	Accuracy of quantitative attributes
Usability	Degree of adherence of a data set to a specific set of user requirements

The data quality elements presented in *Table 5* should be used to structure the reporting of quality evaluation.

Measurable quality of a dataset should be described using the data quality elements that are presented in *Table 5*. Data quality overview elements can be used to describe non-quantitative quality. Overview elements are purpose, usage and lineage, which are specified in the ISO 19115-1 standard, see section *2.2.* It should be noted that the standard doesn't require the use of only the quality elements that are described in the standard. *Figure 6* presents an overview of the components and the connections between them described in the standard.

The standard defines how a data quality element should be reported using quality descriptors. Those are:

- Data quality scope
- Data quality measure
- Data quality evaluation method
- Data quality result

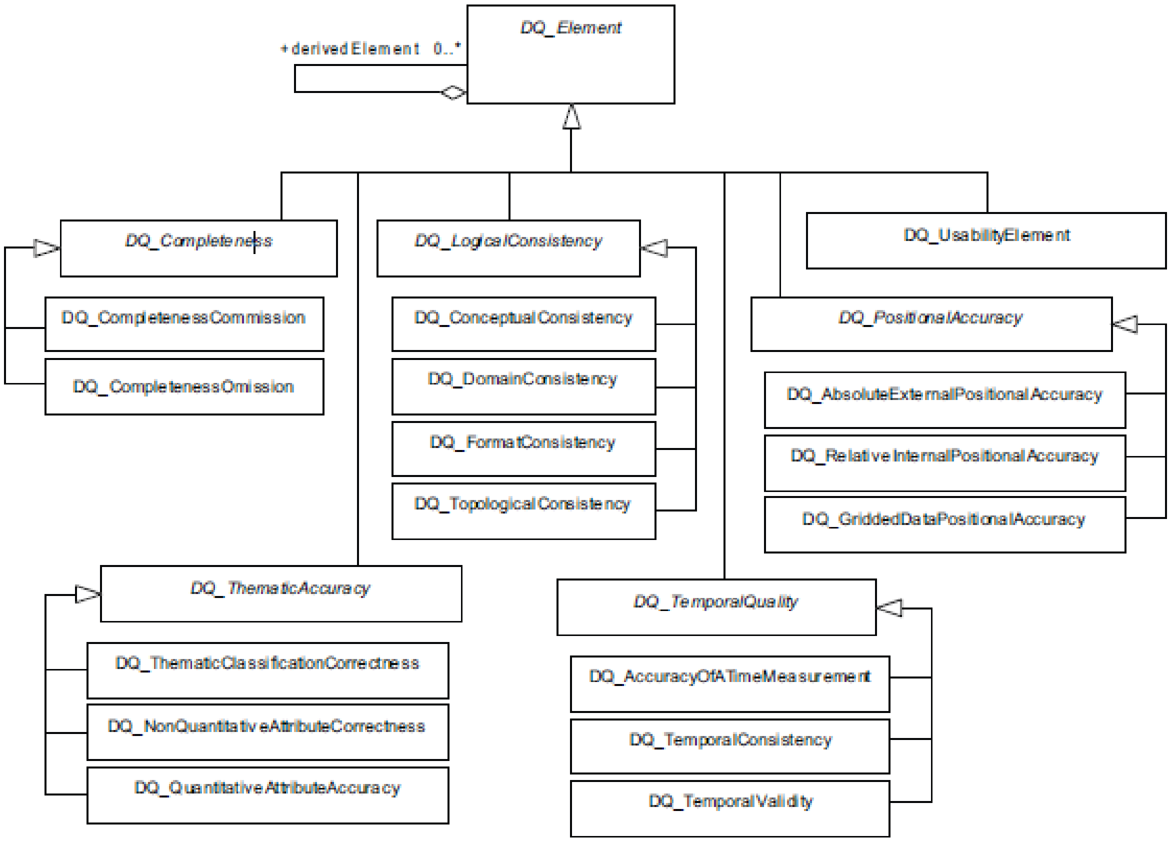

Figure 6 Overview of the categories and elements of Data Quality

2.7.3. Description of Quality evaluation procedures

The purpose of the quality evaluation procedures is to:

- Provide a framework of procedures for determining and evaluating quality of geographic datasets
- Establish a framework for evaluating and reporting data quality results, as part of metadata or as a data quality report

The standard describes a general process flow to guide the data quality evaluation process. Basically it is a 6-step procedure:

Step 1: Identify an applicable data quality element and data quality scope
Step 2: Identify, for each element and scope, a suitable data quality measure
Step 3: Select and apply a data quality evaluation method
Step 4: Determine the data quality result
Step 5: Determine conformance
Step 6: Report on results and /or conformance

After step 4 results may be reported if a user of the procedure wants to report quantitative result and after step 5 conformances to quality requirements may be reported if product specifications include those.

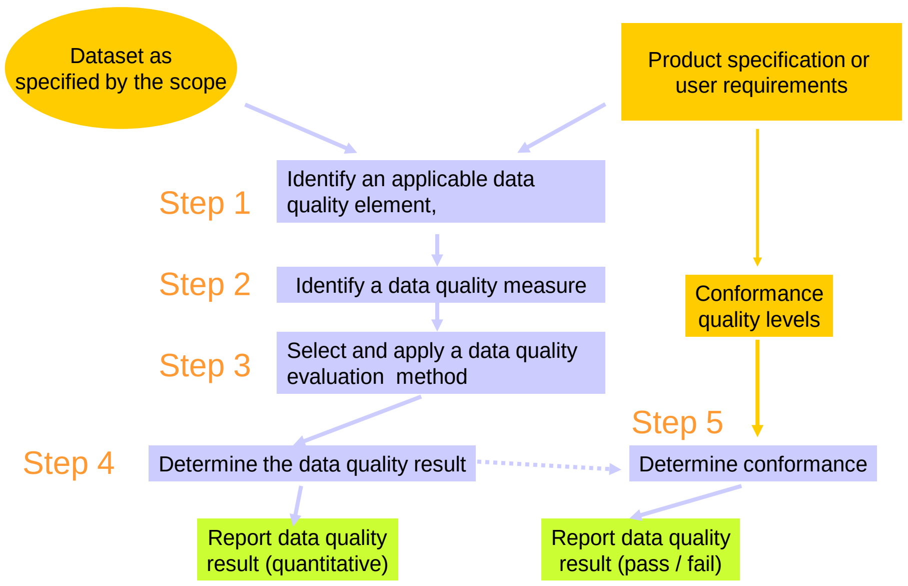

Figure 7 Data Quality Evaluation Process

The standard classifies data quality evaluation methods as direct and indirect quality evaluation methods. Direct evaluation methods can be either internal or external. An example of internal direct quality evaluation is a logical consistency test that can be performed using a dataset by itself. External direct evaluation occurs when an external dataset or the real world is used as a reference against which the dataset is evaluated. Indirect evaluation methods use external knowledge such as usage, lineage and purpose.

Techniques for direct evaluation are full inspection or sampling. The standard suggests using general sampling standards such as ISO 2859 and ISO 3951. Informative annex of the standard provides information on how to select appropriate sampling strategy.

The standard specifies the fields to be filled in when reporting on assessment as a quality evaluation report (described in the metadata fundamental standard):

- Identification of reporting document
- Scope observed
- Measure used (formula, resulting values, result unit, reliability, reliability unit)
- Confidence in conformance test (confidence value, confidence unit, documents explaining the method)
- Type of quality evaluation method used (direct external etc., inspection strategy applied)
- Description of quality method used (basic assumptions, processing algorithms, definition of parameters, parameter values for the specific test, parameter units)
- Possible aggregation of results (unit for aggregated values, resulting values, statistics used for aggregation, computation date, pointer to aggregation report)
- Other descriptions may be provided if necessary

Table 6 provides an example of usage of the standard. DQ_elements see *Table 5*. DQ_measures are described in *2.7.4*. Data producers should describe the conformance levels (e.g. in the data quality model). ISO 19157 does not describe the evaluation procedures so the producers should apply e.g. ISO 2859 standard for this. DQ_values are obtained from the evaluation process. If conformance quality levels have been described then the conformance result is either accepted or rejected.

Table 6 Examples How to Use ISO 19157 Standard

categories of DQ_element	Part of categories	DQ_measure	DQ_conformacelevel	DQ_EvalProcedureDesc	DQ_value
Completeness	Omission	Number of missing items	Declared Quality Level (DQL) 2,5 % (based on ISO 2959-4 standard)	Stratified random sampling using inspection of items in the field. Sample size 32 items	Accepted (Number of missing items 1)
Logical consistency	Domain consistency	Number of items not in conformance with their value domain	0	Full inspection	Rejected (Number of wrong items 1)
Positional Accuracy	Absolute of external accuracy	RMSE	2 m	Random sample	Accepted (RMSE 1,5 m)

2.7.4. Description of the data quality measure

The objective of the part is to guide the producer in choosing the right data quality measures for data quality reporting and the user in the evaluation of the usefulness of a dataset by standardising the components and structures of data quality measures and by defining commonly used data quality measures.

It defines a set of data quality measures that can be used when reporting data quality for the data quality elements. The idea is to build a register of standardized quality measures. It does not limit users from defining their own quality measures.

Each quality measure is described by a set of components (see *Table 7*). Specification includes a list of data quality basic measures that can be used to describe quality measures (see *Table 8*)

Table 7 Components of Quality measures (Summarized from chapter 8.6 ISO 19157)

Component	**Description**	**Obligation M=mandatory, O=obligatory, C=conditional**	**Comments/Examples**
Name	Name of the data quality measure.	M	
Alias	Other recognised name for the same data quality measure.	O	
Data quality element	The name of the data quality element to which this data quality measure applies. See Chapter 7.5 in ISO 19157	M	
Data quality basic measure	Name of data quality basic measure	C	Technical specification lists a set of data quality basic measures that can be used. The user can define their own data quality basic measure. Its is typically based on counting of erroneous items, dealing with uncertainty or general statistical measures
Definition	Statement of the fundamental concept of the data quality measure	M	
Description	Description of the data quality measure including method of calculation with all formulae and/or illustrations needed to establish the result of applying the measure.	C	If the definition is not sufficient to understand the data quality measure concept. Example: what is not measured, not counted, what other measures should be used to help interpret the results.
Parameter(s)	Auxiliary variables used by the data quality measure including name, definition and description.	C	There can be one or many parameters
Data quality value type	Value type for reporting a data quality result.	M	Examples include Boolean, real, integer, ratio, percentage or measure(s) (values+ units)
Data quality value structure	Structure for reporting a complex data quality result	O	Bag, Set, Sequence, Table, Matrix, Coverage

Component	Description	Obligation M=mandatory, O=obligatory, C=conditional	Comments/Examples
Source reference	Citation of the source of the data quality measure.	C	If an external source exists
Example	Example of applying the data quality measure or the result obtained for the data quality measure.	O	
Identifier	Integer number, uniquely identifying a data quality measure.	C	If data quality measures are administered in a register

Table 8 Basic Data Quality Measures (See Table G.1 ISO 19157, Examples are Modified from the Standard)

Data quality basic measure name	Data quality basic measure definition	Examples
Error indicator	Item is in error	True (item is not correct)/False (item is correct)
Correctness indicator	Item is not in error	True (item is correct) / False (item is not correct)
Error count	Total number of items that are subject to an error of a specified type	10 (number of incorrect items)
Correct items count	Total number of items that are free of errors of a specified type	200 (number of correct items)
Error rate	Number of the erroneous items with respect to the total number of items that should have been present	Error rate can be real, percentage or ratio. Note: Total number of items that should have been present should also be reported if real or percentage is used.
Correct items rate	Number of the correct items with respect to the total number of items that should have been present	See above.

The technical specification includes a comprehensive list of the measures (currently 75). *Table 9* describes some quality measures for the NMCAs that were currently identified in the standard. Some of the quality elements have no appropriate quality measures at the moment.

Table 9 Selected Important Quality Measures for the NMCAs

Data quality element category	**Data quality element**	**Data quality measure**	**Data quality basic measure**	**Identifier**	**Examples**
Commission	Commission	Number of excess items	Error count	2	
Commission	Omission	Number of missing items	Error count	7	
Logical consistency	Conceptual consistency	Number of items noncompliant to the rules of the conceptual schema	Error count	11	
Logical consistency	Domain consistency	Number of items not in conformance with their value domain	Error count	17	
Logical consistency	Topological consistency	Number of faulty point-curve connections	Error count	22	Two roads in a junction don't meet
Logical consistency	Topological consistency	Number of missing connection due to undershoots	Error count	24	
Logical consistency	Topological consistency	Number of missing connections due to overshoots	Error count	25	
Positional accuracy	Absolute or external accuracy	Mean value of positional uncertainties (1D, 2D and 3D)	Not applicable	29	This is applicable when a set of co-ordinates considered to be true exists. 2D: $e_i = \sqrt{(x_{mi}-x_{ti})^2 + (y_{mi}-y_{ti})^2}$ 3D: $e_i = \sqrt{(x_{mi}-x_{ti})^2 + (y_{mi}-y_{ti})^2 + (z_{mi}-z_{ti})^2}$ $\bar{e} = \frac{1}{N}\sum_{i=1}^{N} e_i$
Positional accuracy	Absolute or external accuracy	Mean value of positional uncertainties excluding outliers (2D)	Not applicable	30	Same as quality measure with identifier 29 except all positional uncertainties above a defined threshold are removed from the set.
Positional accuracy	Absolute or external accuracy	Covariance matrix	Not applicable	33	

Data quality element category	Data quality element	Data quality measure	Data quality basic measure	Identifier	Examples
Positional accuracy	Absolute or external accuracy	RMSE	Not applicable	41	Standard deviation, where the true value is not estimated from the observations but known a priori $\sigma_z = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(Z_{mi} - z_t)^2}$
Temporal accuracy	Temporal validity	Number of items not in conformance with their value domain	Error count	17	Buildings in a dataset should have been reviewed in 2006. By mistake some of the buildings were not reviewed. Measure for temporal validity might then be number of non-valid review dates of buildings
Thematic accuracy	Classification correctness	Number of incorrectly classified features	Error count	62	
Thematic accuracy	Classification correctness	Misclassification matrix	Not applicable	64	Matrix that indicates the number of items of class (i) classified as class (i) The diagonal elements of the misclassification matrix contain the correctly classified items, and the off diagonal elements contain the number of misclassification errors.
Thematic accuracy	non-quantitative attribute correctness	Number of incorrect attribute values	Error count	67	

Table 10 identifies some of the existing measures used in NMCAs that are not currently included in the specification.

Table 10 Quality Measures used in NMCAs

Data Quality element category	Data Quality element	Data quality measure	Data quality basic measure	Country	Examples
Positional accuracy	Absolute or external accuracy	Mean normalized fluctuation of linear features	Database to Universe of discourse component of the Hausdorff distance between line in database and line in	France	$\overline{ErrLin_{DT \to UD}} = \frac{2}{n}\sum_{i=1}^{n}\frac{Max_{p \in L_{DT_i}} \; Min_{q \in L_{UD_i}} \; d(p,q)}{Length(L_{DT_i}) + Length(L_{UD_i})}$

Data Quality element category	**Data Quality element**	**Data quality measure**	**Data quality basic measure**	**Country**	**Examples**
			universe of discourse		
Temporal accuracy	Accuracy of a time measure ment	Mean value of date attributes	Difference between date in database and date in universe of discourse	France	$\bar{d} = \frac{1}{n}\sum_{i=1}^{n}\left(d_{DB_i} - d_{UD_i}\right)$

Table 11 depicts the number of measures that are identified in the standard for each element category and element.

Table 11 Number of Measures for Each Element category and element

Element category/element	Number of measures per basic measure							Total
	Error indicator	Error count	Error rate	Error ratio	Correct items rate	Correctness indicator	Not applicable	
Completeness								9
Commission	1	2	1		1			5
Omission	1	1	1		1			4
Logical consistency								20
Conceptual consistency	1	2	1		1	1		6
Domain consistency	1	1	1	1		1		5
Format consistency		1	1					2
Topological consistency		6	1					7
Positional accuracy								37
Absolute or external accuracy		1					24	25
Relative or internal accuracy							2	2
Gridded data position accuracy							10	10
Temporal accuracy								11
Accuracy of time measurement							6	6
Temporal consistency								0
Temporal validity	1	1	1	1		1		5
Thematic accuracy								14
Classification correctness		1	1				3	5
Non-quantitative attribute correctness		1	1		1			3
Quantitative attribute accuracy							6	6
Total								91

2.7.5. Description of metaquality

Metaquality is the quality of quality information and may also be reported, see *Figure 4* Conceptual model of quality for geographic data. A metaquality element is described as the quality element (measure, evaluation method and result) with the related quality element added. Information about confidence, representativity and homogeneity may also be described, see E.5.3 in EN ISO 19157 for an example.

By using this technical specification for the metadata, the data owner makes the quality information available, for GIS application systems, cataloguing services, producers and suppliers of geographic data, and so on.

2.8. CD ISO 19157 Geographic Information – Data quality - Part 2: XML schema implementation of ISO 19157

2.8.1. Current status

Part 2 is under development and is planned to be published in the middle of 2016.

2.8.2. Description of content

This technical specification defines eXtensible Markup Language (XML) schemas for encoding 19157 Data quality content.

3. Implementing the Quality Standards at the NMCAs

3.1. Identifying Your Needs

This chapter can be used to create a position paper for introducing quality based on ISO standards for the management board of your organization. In Chapter 4 we introduce different strategies, which organizations could utilise to start the implementation process. Position papers should clearly identify the selected strategy. It should be noted that implementation of the standards is a long process and organizations normally have some existing parts. These should be utilized in the process. In general a pilot project that gives a success is a good strategy to follow.

It is very important, when starting to implement the ISO standards, to identify your needs. Customer requirements are in general the most important issue to take into account when you start implementing quality standards. There are several different viewpoints you should consider:

- quality requirements (stated or implied) as conformance quality levels
- cost of quality evaluation
- reporting quality
- legal requirements.

Spatial data infrastructures should be taken into account when considering quality implementation.

Based on customer and other requirements you should first select a set of quality categories and elements from the ISO 19157 standards.

The standard should not be considered as a list of mandatory requirements , but as reminders of major issues that have to be tackled. Standards are helpful reminders of what may be desirable in general. Standards will also change over time.

ISO 19100 Geographic Information Standards have been designed as a suite of standards supporting each other. Therefore one standard does not necessarily give the whole picture and may create problems if taken in isolation. These problems may be solved in other standards of the same family. A set of standards is usually needed to understand how to use one standard.

The ISO approach is implementation-oriented therefore it is relatively easy to implement a standard. However, most of the quality standards remain at a rather general descriptive level.

Based on your inventory of needs, ISO 19131 may be a good starting point to help you start the implementation process.

3.2. Understanding How to Address the Standards

The implementation process should follow the normal procedure used internally for project management for each NMCA. You may also see the Expert Group on Quality report on project management[13].

Identified methods are:

1. Getting the knowledge/information standards
    - Directives (INSPIRE including data specifications)
    - ELF/ESDIN Project
    - CEN technical report: Geographic Information – Standards, specifications, technical reports and guidelines, required to implement a Spatial Data Infrastructure
    - National recommendations
    - Textbooks (ISO 19100)
    - Standards (ISO 19115-1, ISO 19115-2, ISO 19157, ISO 19131, ISO 19158)
2. Find out about success stories.

    Some of the good implementations are mentioned in Chapter 5. ISO Focus group on data providers has produced information on the implementation[14]. ISO TC 211 also has information/presentations “standards in action” available on its web pages[15]. Benchmarking is good way to extract the knowledge from other similar organizations.

3. Assess the benefit of ‘spirit-conformance’ versus ‘letter-conformance’ i.e. conforming with the intent of the Standard as against the literal interpretation

4. Assess the benefit of effective implementation vs. documented translation of your own activities into the standards’ terms.

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[13] See Expert Group Publications in http://www.eurogeographics.org/eng/05_quality.asp

[14] http://www.isotc211fgdp.info/

[15] http://www.isotc211.org/

3.3. Guidance on where to start the implementation

Table 12 describes where a national mapping agency should start the implementation of quality standards.

Table 12 Guideline to Implementing the Standards

Phase	Goal	ISO standard	Guidance
Data specification	Quality model	ISO 19131	General guidance can be found from ISO 19131 ISO 19157 explains how you can set the quality conformance levels
Production	Logical consistency tests	ISO 19157	This is normally carried out by automated full inspection. There are some independent software tools available in the market for testing logical consistency. The most important phase is to determine the rules that have to be followed. For software tools see Appendices.
	Producing metadata	ISO 19115-1, ISO 19115-2, ISO 19157	This should be incorporated in your production process and software.
	Quality measures for a database	ISO 19157, ISO 19115-1, ISO 19115-2,	These measures are usually based on the quality model.
Quality evaluation	Quality tests	ISO 19157, ISO 2859-4 ISO 3951-1	ISO 2859 standards may be considered for sampling. Especially ISO 2859-4 and ISO 3951-1 might be useful for evaluation purposes. For positional accuracy some standards exists that might be valuable[16]
Delivery	Quality assurance	ISO 19158	Provides a framework for quality assurance specific to geographic information.
Metadata	Reporting quality	ISO 19115-1, ISO 19115 -2	Conformance to specification should be reported. In the future numerical results may be useful for different applications.
Exchange of metadata	Metadata catalogues Metadata to customers	ISO 19139	Encoding of metadata using Extensible Markup Language (XML)

3.4. Implementing common quality elements at the NMCAs

3.4.1. Where to find certain quality phenomenon in the standards

Some quality elements are not clearly addressed in the ISO 19100 series. Here we discuss some possible implementations for currency, completeness and coverage. Currency or up-to-dateness indicates how well a dataset represents the real world in respect of time (usually present, however, historical databases are not excluded). Real-word features are changing constantly and databases are updated either constantly (but in practice always after real-word change) or in some defined update cycles. If a producer makes an evaluation of how many features have changed over a period of time then this

[16] See for example: STANAG 2215 Standardization agreement: Evaluation of land maps, aeronautical charts and digital topographic data. North Atlantic Treaty Organization, Brussels 2002.

evaluation is valid only for that date. The quality element **completeness** is used in the ISO standard to report how many errors were found e.g. 2 missing features and 2 additional features. Currency might be reported as 4 changed features over six months (average of time differences between data collection and evaluation) and date of the evaluation or update. In order to estimate the currency of a dataset a user could use this information together with information about feature type (e.g. buildings) and number of updates or changes made in a database after evaluation. However, it might not be valid in a certain area e.g. there might be a new residential area or motorway construction that is not following average figures. More discussion of currency can be found in *Fundamentals of Spatial Data Quality.*[17]

Possible measures of currency are described in *Table 13*.

Table 13 Possible Measure of Currency

Measure	**ISO 19100 quality element/sub-element**	**Comments**
Units of change over period of time	metadata LI_Lineage Temporal quality/ new element: currency	There are two options a producer can select. It can be reported as lineage information or producer can make a new sub-element under temporal accuracy
Date of last update	metadata LI_Lineage or as metadata CI_Data (date of last revision)	This can be reported as lineage for a certain area if updating is based on a certain area. Feature instance in the database should contain valid from or change date. Alternatively, it can be reported as a date of last revision.
Rate of change	metadata LI_Lineage	An estimate of change of feature types over period of time
Temporal validity	Temporal accuracy/Temporal validity	Validity of data with respect of time. e.g. valid/non valid/not_yet_valid
Update frequency	Lineage or as metadata MD_MaintenanceInformation	Planned update based on quality model
Temporal extent	Metadata MD_DataIdentification/ EX_Extent/ EX_TemporalExtentent	Time period covered by the content of the resource

National coverage is an important issue for the NMCAs. Normally the target for a NMCA is to achieve national coverage. Therefore it is important to give an indication if a database covers the whole country. Coverage information can be described in metadata (GeographicExtent) according to the ISO 19115-1 standard.

[17] Devillers R and R. Jeansoulin eds. Fundamentals of Spatial Data Quality, ISTE, 2006: Chapter 8 page 146.

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4. Strategies for implementing standards

4.1. Standards and Profiles

The ISO 19100 is a series of standards for defining, describing, and managing geographic information, i.e. information concerning objects or phenomena that are directly or indirectly associated with a location relative to the Earth. This series of standard specifies methods, tools and services for management of information, including the definition, acquisition, analysis, access, presentation, and transfer of such data in digital/electronic form between different users, systems and locations.

ISO/TC211 is responsible for the development of international standards in this area of digital Geographic Information. These various standards can be organised into themes for a Geographic Information Technology Framework

Architecture and Framework,

Metadata, Data Content and Definitions,

Core Data Model,

Data Exchange Formats,

Data Interchange and Services,

Data Quality,

Spatial Referencing,

Imagery.

This series of standards make it possible to define profiles in order to facilitate the development of geographic information systems and application systems that will be used for specific purposes. Profiles and functional standards consider the technique of profiling which consists of putting together “packages/subsets” of the total set of standards to fit individual application areas or users. This supports rapid implementation and penetration in the user environments due to the comprehensiveness of the total set of standards.

An organization however cannot do whatever it pleases and pretend it has designed a standard profile Notably, concerning the information to be provided (i.e. the “requirements”, in standard terminology), there are *mandatory* fields and sections in the standards: these cannot be dispensed with in the profile. *Conditional* fields are obligatory fields, under certain logical conditions. The *optional* fields can be discarded, when irrelevant, or they can be systematized within the profile, if they are felt to be important for the organization. An organization may also add its own requirements (“additional requirements”), provided this is done with respect to what is allowed by the standards themselves (which usually describe how things may be added).

The resulting decisions make the profile. Also, the explanations for the choices should be documented.

They may decide to focus on a specific Product or Dataset profiles. An explicit document will specify how the standard should be used for different products or even datasets. The benefits for such an approach include a closer relationship with each product. Disadvantages include the management overhead for the maintenance of multiple product or dataset profiles.

The organization may focus on the definition and use of an Organizational profile for all products. The one document will act as a template and specify how the chosen standard is to be used throughout the organization. The advantages of such an approach include the easier development and maintenance of automated tools to make the data and information flow throughout the organization consistent with the standard. It also ensures some kind of consistency of description and structuring over the various products. Disadvantages of this approach include that the reference document (explaining the profile) may become voluminous and require significant resources to maintain it.

Ideally, from a management perspective, the twinning of the two profiles Product or Dataset and Organisational could be a powerful and consistent double bind (which is not easy to obtain, nor to make last. Of course, a logical hierarchy of profiles is desirable, for efficiency reasons. Thus, a specific Product or Dataset profile should be compliant with the Organizational profile (when the dataset involved is related to the organization’s general purpose for which the organizational profile is meant). Under the same condition, the Organizational profile should be National-profile-compliant; and the National profile itself should be European-Profile-compliant.

Figure 8 illustrates the different profiles that may be required for implementing the standard

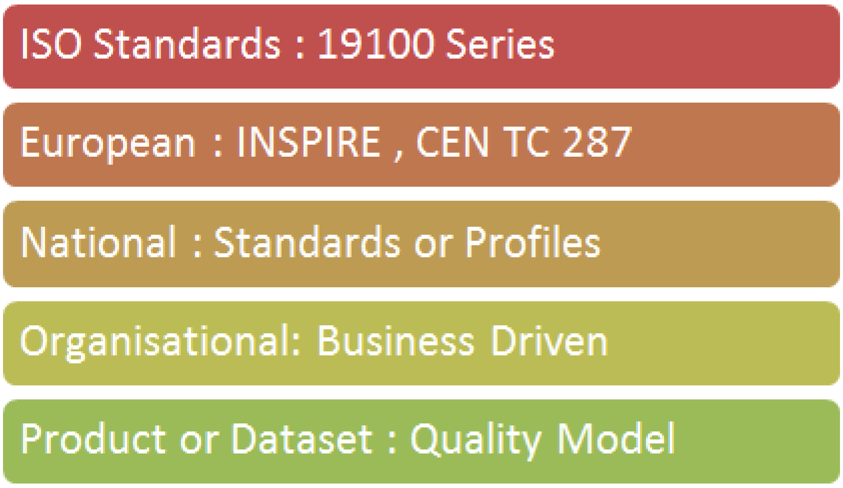

Figure 8 Different Profiles and Levels

Facilitating access to and reuse of spatial data is the main goal of spatial data infrastructures (SDIs). In Europe , the legal and technical framework for European SDI is defined by the Infrastructure for Spatial Information in the European Community (INSPIRE) Directive 2007/2/EC and its related implementing rules and technical guidelines. The Directive came into force on 15 May 2007 and sets out requirements for standardisation and publication of geographical datasets, associated dataset descriptions (metadata) and access services, across the European Union.

All EU Member States enacted national legislation in 2010 adopting the Directive. The European Commission has since published several EC Regulations covering operational aspects for implementation of the Directive. These apply to all Member States; at dates according to the current official INSPIRE 'Roadmap', which extends to 2020. This is in essence the European profile that all EU member states are working towards.

4.2. Quality models for datasets

A quality model may best be described as a conceptual framework in how to determine and report quality. The EuroGeographics QKEN defined a A quality model as a framework for measuring and presenting the quality of a spatial dataset. It contains a number of distinct parts some of which may not be applicable to some datasets.

These are:

- An assessment of the quality requirements of the dataset usually expressed in terms of quality elements as defined in 19157.

- The identification of the evaluation methods, usually defined in terms of ISO 19157

- The identification of the metadata recording process defined as described in ISO 19115-1 or in a quality report.

In addition to this the model may include the following:

- Details of any additional methods used to control quality in the production flowline such as (but not limited to) validation tools, quality control, quality assurance or accreditation

- Details of any post flowline testing

- The required quality levels

The recent ISO 19157:2013 establishes the principles for describing the quality of geographic data. It:

Defines components for describing data quality;

Specifies components and content structure of a register for data quality measures;

Describes general procedures for evaluating the quality of geographic data;

Establishes principles for reporting data quality.

ISO 19157:2013 also defines a set of data quality measures for use in evaluating and reporting data quality. It is applicable to data producers providing quality information to describe and assess how well a data set conforms to its product specification and to data users attempting to determine whether or not specific geographic data are of sufficient quality for their particular application. Please note however that this standard does not attempt to define minimum acceptable levels of quality for geographic data as it will be up to each data producer to determine such levels.

This standard suggests the quality evaluation process is a series of steps

This new standard indicates that Data quality should be reported as metadata in compliance with Clause 7, Annex C, ISO 19115-1:2013 and ISO 19115-2:2009. In order to provide more details than reported as metadata, a standalone quality report may additionally be created. Its structure is free however; the standalone quality report shall not replace the metadata. The metadata should provide a reference to the standalone quality report when it exists. There are further details and examples on how to report on data quality in the standard annexes.

The ESDIN (European Spatial Data Infrastructure Network) consortium was co-ordinated by EuroGeographics and supported by funding from the European Commission. The consortium successfully showed how data from European National Mapping and Cadastral Agencies (NMCAs) could be harmonised to meet INSPIRE obligations whilst also addressing issues such as generalisation , quality evaluation, edge matching and spatial data infrastructures (SDI) access control The project started in September 2008 and ended in February 2011. Amongst the public deliverables are Metadata and Quality Guidelines Here at http://www.esdin.eu. Whilst it does provide a very useful guide to the implementation of standards, it was based on the ISO quality standards of the time: ISO 19113, ISO 19114, ISO 19115, ISO 19138 and the INSPIRE data specifications v2.0.

4.3. Responsibility, Communication and Training (internal/external)

The strategic decision to implement a profile must have the support and endorsement of the Senior Management Team in order to be successful. They need to champion the role and implementation of the profile as a framework to drive continual improvement and business objectives. This may be achieved through the creation of a Business Sponsor, a Senior Manager from the business who will have the necessary credibility and influence.

Two fundamental elements of a successful implementation are Communications and Training. The two sets of activities must be closely linked and it is often a good idea to use the same team to develop and deliver both.

Table 14 introduces different communication and training needs based on the idea of profiles.

Goal	Target Audience	Topic	Training	Role of this Guideline
Common profiles/models between NMCAs	European Spatial Data Infrastructure	Interoperability between countries		This guideline can be used in the process of making the profile.
National Quality Profile	National Spatial Infrastructure players	Role of quality in reference datasets	Parties who will make a National Profile	This guideline can be used to make a national profile. See also national examples if available.
	Students and personnel in the field of geographic information		Basic knowledge of ISO standards and quality	This guideline can be used in the training process
Organizational Quality Profile	Head of the organization	Benefits and cost of organizational profile	Staff who will make an organizational profile	This guideline can be used to make a position paper.
	Subcontractors	How organizational profile will change contractors work		General knowledge of quality standards
	Personnel	Benefits for their work and how their work will be affected		Use guideline to make an organizational profile
Dataset Profile	Department that is responsible for the dataset	Benefits and costs		This guideline can be used to make a dataset profile. Sometimes it is helpful to make a case before making an organizational/national profile
Quality Model	Customers & the Department that is responsible for the dataset.	Improvement of communication of data quality	Use of data quality measures from the user aspect	Large customer organizations can use this guideline to verify quality models

5. Experiences at the NMCAs

A number of European NMCAs have successfully implemented the ISO standards. Documentation (and the location of it) changes frequently and rather than try to describe these in great detail here, the reader is advised to contact the countries directly for the latest information. There are some public documents listed in the Appendix but most NMCAs hold more information than that which is available on their website.

Good examples of the implementation of the ISO Standards can be found in Sweden, France, Finland, Germany and Greece. In addition, the ESDIN project (which has morphed into ELS) created a very good Data Quality Model based on the ISO Standards.

Appendices

Some example documents that are available:

National profiles

Name of the document (in English and national languages)	Purpose	Relevant ISO standards	Responsible organization	Link to the publication
National recommendation on quality (Finland)	Profile of ISO 19113, ISO 19114, ISO 19138	ISO 19113, ISO 19114, ISO 19138	JUHTA (advisory board for public administration recommendations) Document has been produces by the national geoinformation council	Available in Finnish only http://www.jhs-suositukset.fi/suomi/jhs160
National metadata profile	Profile of ISO 19115	ISO 19115	JUHTA	Available in Finnish only http://www.jhs-suositukset.fi/suomi/jhs158
National metadata profile in France	GI Interoperability at a European level	ISO 19115	CNIG	www.cnig.gouv.fr

Organizational/Domain profiles

Name of the document (in English and national languages)	Purpose	Relevant ISO standards	Responsible organization	Link to the publication
EuroRoadS Quality documentation: D2.4 Quality Management Concept	Quality management of Road Data	ISO 9000	EuroRoadS project	http://www.euroroads.org/php/Reports/D2.4%20Quality%20management_FD0.1.pdf
D2.3 Probabilistic model to describe and evaluate information quality	A probabilistic model to describe and evaluate quality of geoinformation within data providing processes	None	EuroRoadS project	http://www.euroroads.org/php/Reports/D2.3.pdf
ISO 19131 profile for IGN (France)	Profile	ISO 19131	IGN	See table below.
ISO 19115 profile for IGN	Profile	ISO 19115	IGN	See table below.

Meant as examples of IGN-F's organizational profiles, the following tables are extracted from IGN's ISO 19131 and ISO 19115 standards.

Extract from IGN-F's ISO 19131 profile (2004)

2.5.3. Maintenance

Description de la périodicité de maintenance du produit (champ « resourceMaintenance » de la Table 2.5). Elle correspond à l'ensemble `MD_MaintenanceInformation` de la norme 19115. L'identifiant est "`{PRODUIT_EE-RR}.resourceMaintenance_i`":

Nom	Définition	Utilisation dans le profil
maintenanceAndUpdateFrequency	Fréquence de mise à jour du produit	- `continual` (MaintFreqCd001) - `daily` (MaintFreqCd002) - `weekly` (MaintFreqCd003) - `fornightly` (MaintFreqCd004) - `monthly` (MaintFreqCd005) - `quartely` (MaintFreqCd006) - `biannually` (MaintFreqCd007) - `annually` (MaintFreqCd008) - `asNeeded` (MaintFreqCd009) - `irregular` (MaintFreqCd010) - `notPlanned` (MaintFreqCd011) - `unknown` (MaintFreqCd012) - `pluriannually` (propre IGN) Pour un produit externe, il s'agit de la fréquence du produit interne qui à partir duquel il est constitué.
dateOfNextUpdate	Date de la prochaine mise à jour	*Non utilisé*
userDefinedMaintenanceFrequency	Période ou durée de la maintenance	*Non utilisé*
updateScope	Portée de la maintenance du produit	*Non utilisé*
updateScopeDescription*	Information sur la portée de la maintenance du produit	*Non utilisé*
maintenanceNote*	Information sur la maintenance du produit	Si fréquence variable ou si besoin.
contact*	Identification des personnes et organisations associées à la maintenance du produit	*Non utilisé*

Table 2.5.3. MD_MaintenanceInformation

Extract from IGN-F's ISO 19115 profile (2005)

2.7. Qualité

Information sur la qualité de l'agrégat (champ « dataQualityInfo » de la Table 2). Il correspond à l'ensemble `DQ_DataQuality` de la norme 19115 :

Nom	Définition	Utilisation dans le profil
scope	Données tests sur lesquelles s'applique les informations	Cf. Table 2.7.1
*report**	Mesures de qualité effectuées	Cf. Table 2.7.2
lineage	Information sur la généalogie	Référence aux informations sur la généalogie du produit : `{PRODUIT_EE-RR}.lineage` ou Cf. Table 2.7.3

Table 2.6. DQ_DataQuality

2.7.1. Données test

Information sur les données tests pour la qualité de l'agrégat (champ « scope » de la Table 2.7). Il correspond à l'ensemble `DQ_Scope` de la norme 19115 :

Nom	Définition	Utilisation dans le profil
level	Domaine des données tests	- `attribute` (ScopeCd001) - attributeType (ScopeCd002) - collectionSession (ScopeCd004) - dataset (ScopeCd005) - series (ScopeCd006) - feature (ScopeCd009) - featureSession (ScopeCd010)) La valeur `collectionSession` doit apparaître une fois et une seule
extent	Étendue des données tests	*Non utilisé*
*levelDescription**	Description détaillée des données sur lesquelles le critère s'applique	Au choix : - Identifiant de l'attribut - Identifiant de la classe/relation - Identifiant du lot de données - Autre (e. g., échantillon de 80km^2 pris sur les zones de raccord de bloc)

Table 2.7.1. DQ_Scope

2.7.2. Mesures de qualité

Information sur les mesures de qualité de l'agrégat (champ «report» de la Table 2.7). Il correspond à l'ensemble `_DQ_Element` de la norme 19115. Cet ensemble est abstrait, sa mise en oeuvre est couverte par les éléments de la qualité DQ_CompletenessCommission, DQ_CompletenessOmission, DQ_ThematicClassificationCorrectness, DQ_NonQuantitativeAttributeAccuracy, DQ_QuantitativeAttributeAccuracy, DQ_ConceptualConsistency, DQ_DomainConsistency, DQ_FormatConsistency, DQ_TopologicalConsistency, DQ_AccuracyOfATimeMeasurement, DQ_TemporalConsistency, DQ_TemporalValidity, DQ_AbsoluteExternalPositionalAccuracy, DQ_GriddedDataPositionalAccuracy et DQ_RelativeInternalPositionalAccuracy :

Nom	Définition	Utilisation dans le profil
nameOfMeasure*	Nom de la mesure	Génération manuelle (Cardinalité = 1)
measureIdentification	Information sur la mesure	*Non utilisé*
measureDescription	Description de la mesure	Génération manuelle
evaluationMethodType	Type d'évaluation de la mesure	- `directInternal` (EvalMethTypeCd001) - `directExternal` (EvalMethTypeCd002) - `indirect` (EvalMethTypeCd003)
evaluationMethodDescription	Description de la méthode d'évaluation	Génération manuelle
evaluationProcedure	Information sur la méthode d'évaluation	*Non utilisé*
DateTime	Date de l'évaluation	Au format : `SSAA-MM-JJ`
result*	Résultat quantitatif et de conformité (2 occurrences max)	Cf. Tables 2.7.2.1 à 2.7.2.3

Table 2.7.2. _DQ_Element

Quality models

Name of the document (in English and national languages)	Purpose	Relevant ISO standards	Responsible organization	Link to the publications
EuroRoadS Quality documentation: D2.6 Final Report on Quality Evaluation	Summary on EuroRoadS quality management concept and the experiences of its implementation in different test sites.	ISO 9000, ISO 19115	EuroRoadS project	http://www.euroroads.org/php/Reports/D2.6%20Report%20on%20Quality%20evaluation.pdf
Quality model for the Topographic Database (Finland)	Description of quality element, sub-element, measures, quality requirements and test methods	ISO 19113, ISO 19114, ISO 19138 ISO 19157	National Land Survey of Finland	Current version is not available in English

Software for quality assurance

Name of the software	**Related standards**	**Responsible organization**	**Link to the homepage**
1Integrate	ISO 19107 GML3 ISO 19157	1Spatial	https://1spatial.com/products/
ArcGIS Data Reviewer	ISO 19107 ISO 19157	ESRI	https://www.esri.com/en-us/arcgis/products/arcgis-data-reviewer/overview
FME	ISO 19157	Safe Software	https://www.safe.com/fme/fme-desktop/

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