SDI and Metadata Entry and Updating Tools

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Abstract
Metadata is a vital tool for management of spatial data and plays a key role in any spatial data infrastructure (SDI) initiative. It provides users of spatial data with information about the purpose, quality, actuality and accuracy and many more of spatial datasets. Metadata performs crucial functions that make spatial data interoperable. However, current metadata models and standards are complex and very difficult to handle. Also, metadata for spatial datasets is often missing or incomplete and is acquired in heterogeneous ways.
Typically, it is acquired after the spatial data itself, through lengthy and complex efforts. Metadata is usually created and stored separately to the actual data set it relates to. Separation of storage creates two independent data sets that must be managed and updated - spatial data and metadata. These are often redundant and inconsistent. Thus, the reliability of spatial data and the extent it can be used are often unclear. To respond to this issue, this article discusses the importance of having an integrated system for both spatial data and metadata in which that metadata and spatial data can be integrated within the one spatial dataset, so that when spatial data is updated, metadata related to that data is also automatically updated. The article highlights the significance of spatial data and metadata integration through developing a set of criteria for metadata application development and the result of applying the criteria against a selection of metadata entry tools (METs).

Keywords: Spatial Data infrastructure (SDI), Metadata integration, Metadata Entry Tools, Metadata Update.

1. INTRODUCTION

SDI is an enabling platform that facilitates access to spatial data and sharing spatial resources and tools among different practitioners. The creation of an enabling platform for the delivery of the spatial data and tools will allow users from diverse backgrounds to work together with current technologies to meet the dynamic market place (Rajabifard et al., 2005). Within the enabling platform, metadata plays a key role to facilitate accessing up-to-date and high quality spatial data and services (Williamson et al., 2003).

Metadata is data about data and is a vital component of spatial data. Users of spatial data need to know who created it, who maintains it, its scale and accuracy, and more. It not only provides users of spatial data with information about the purpose, quality, actuality and accuracy of spatial data sets, but also performs vital functions that make spatial data interoperable, that is, capable of being shared between systems. Metadata enables both professional and non-professional spatial users to find the most appropriate, applicable and accessible datasets for use.

According to international definition (ISO/TC211 2001), metadata comprises “… a schema required for describing geographic information and services. Information about

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the identification, the extent, the quality, the spatial and temporal schema, spatial reference, and distribution of digital geographic data …". Metadata are according to ISO/TC211: "applicable to the cataloguing of datasets, clearinghouse activities, and the full description of datasets."

Consistent description of the content and use of spatial data requires standards to define which attributes are needed and the structure of a metadata schema or model. This means that metadata can be used both for human interpretation of data sets, and computer processing and utilisation in search engines.

Different countries and jurisdictions are building many extensive and expensive spatial data systems in which access to up-to-date metadata is vital to delivering high quality spatial data services to their vast areas (Crompvoets et al., 2004). Meanwhile, by increasing distribution of spatial data over the Internet, the demand for spatial metadata to describe spatial data is growing in the networked environment. However, current metadata models are often complex and very difficult to handle. The creation and maintenance of spatial metadata is also seen as an expensive overhead by the spatial data industry (Philips et al., 1998; Najar et al., 2007).

Meanwhile, an integrated model for metadata and spatial datasets will benefit the spatial data industry in general, as well as all industries that increasingly utilise spatial data in their day-to-day tasks. This will enable metadata to be maintained dynamically in a way that addresses the more real-time requirements of people and organisations that use spatial data.

This article aims at discussing the significance of an integrated approach for handling spatial metadata by combining spatial data and metadata in a seamless approach. The methodology used in this article is based on assessing a number of metadata applications in order to reveal the importance of integrated approach. The article is based an ongoing research by authors on the automation of spatial metadata update process.

The article first develops a number of important criteria in coding, developing, installing and exploiting the metadata entry tool. It then reviews and assesses a number of existing metadata entry tools. Based on the result of the assessment, the article presents a discussion on the importance of having an integrated system for both spatial data and metadata.

2. METADATA COLLECTION AND METADATA ENTRY TOOLS

Typically, metadata is collected after the spatial data itself, through lengthy, complex efforts. Metadata for spatial data sets is often missing or incomplete and is acquired in heterogeneous ways. Metadata is usually collected and stored separately to the actual data set it relates to, and is often managed by people with a limited knowledge of its value. Separation of storage creates two independent data sets that must be managed and updated - spatial data and metadata. These are often redundant and inconsistent. Thus, the reliability of spatial data and the extent it can be used are often unclear.

The spatial industry has already identified the major factors about metadata collection and developed a number of applications to manage it. Crucial questions when developing a metadata entry tools are: How can the process of entering metadata be automated for the users? What functionalities should a metadata entry tool provide?, and How can the metadata collection process be facilitated?

A critical problem for metadata collection applications is flexibility. A metadata application must be sufficiently flexible to cope with changes to metadata standards over time and to allow users to extend a standard to cope with local requirements (Waugh, 1998). Also, a key component of supporting flexible metadata applications is user friendliness which can facilitate metadata entry and update.

Overall, the challenge of developing a right metadata entry tool (MET) lies in the structured arrangement of a substantial number of different disciplines and the examination of a large number of factors and issues that are discussed below.

In order to develop a MET, this article categorised the criteria into four main groups including technical requirement, compliance with international standards, user friendly interface and finally availability of necessary functions for handling metadata records.

2.1 Technical requirements

Consideration of technical criteria includes ensuring proper technology development with easy deployment and an efficient database technology to support accessing and maintaining metadata. Technical criteria also should consider the outlay of a MET with a low cost and low risk.

2.1.1 Development technology

There are generally two options for the development of a MET: (1) standalone and (2) web based. As an entry tool a MET is not necessarily required to be a web based application. However, for integration in online search engines, spatial clearinghouses, web base spatial libraries and web mapping systems, a web based development technology will have a better position comparing standalone technologies. Also using a web based technology the tool can be available any time and any where for different range of users.

Meanwhile, the Web places some specific constraints on the development of METs such as the ability to deal with a variety of protocols and formats (e.g. graphics) and programming tasks; performance in terms of speed and size of communication; safety; platform independence; protection of intellectual property; and the basic ability to deal with other Web tools and languages. The web based approach can be helpful for integration of spatial data and metadata which are distributed over the network.

2.1.2 Database Connection Technology

Database Connection Technology provides the connection between a MET and a spatial metadata database. The connection means a link having a formal and published definition for communication in order to record, edit and retrieve metadata. This definition identifies the interface that MET must use to issue query and receive database content through the link.

In this regard, when choosing a MET, the first consideration is the type of databases that the metadata is stored in. Based on the type of database technology, a proper connection technology can be chosen. For instance, Open Database Connectivity (ODBC) and Java Database Connectivity (JDBC) are important technologies as they are available on many disparate platforms and they provide common interfaces to several different database products (Shekhar and Chawla, 2003). More importantly for the integration of metadata and spatial data a comprehensive seamless data should be developed.

2.1.3 Robust code

For further development, when preparing an open source MET, having robust code is essential. Robust coding is a style of programming that prevents abnormal termination or unexpected actions. A robust coded software is easy to follow, well commented, well tested, well-named, has good error messages and can be easily maintained and, if necessary, modified. However this criterion is not applicable when choosing proprietary software with metadata entry facilities.

2.1.4 Easy deployment

When installing a MET, the general deployment process consists of several interrelated activities and transitions between them. With this in mind that every software system is unique, a complete and easy deployment process for a MET should at least include release, installation, activation, deactivation, adaptation and un-installation.

2.1.5 Open source or freeware software

A vendor independent open source modular coding, and, to a lesser extent, freeware, can enable ease of adapting a MET and of future development. For preference, the language should be of an industry standard to match available skills that can be purchased cost effectively from the market place. Similar to the robust code criterion, this factor is not applicable for proprietary software.

2.1.6 Standards

The MET must support international metadata standards that support spatial metadata such as Dublin Core Metadata Standard or ISO 19115:2003 Geographic information – Metadata elements whether core, conditional, mandatory or optional. Besides, the tool should support the implementation of the metadata standards such as ISO 19139:2006, Geographic information – Metadata – XML schema implementation (Moellering et al., 2005).

2.1.7 User friendly interface

Ease of use in a MET includes ensuring consideration of providing an intuitive, simple and familiar user interface to perform the necessary functions and applications. The familiar interfaces would help to hide some very complex operations and provide good navigation logic.

The navigation logic should enable novice, ‘low-end’ users to easily find their way around. The interface should enable novice low-end users to easily create and edit metadata records. This includes consideration of operational and navigational design, graphical and visual design, help information and assistance, the process of entering, editing and retrieving metadata records, and finally technical issues such as response and navigation speed.

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2.1.8 Functionalities

A MET must allow metadata records to be created, edited, copied, compiled, searched, saved and deleted in accordance with the standard Metadata Profile, including not only the mandatory elements but also the remainder of the standard's elements. The basic functionality of the MET should cater for the needs of authors, users and managers of metadata.

The MET should import and export different standards' compliant metadata without the loss of content. To enable ease of human readability and presentation the MET should also produce valid text files such as HTML or RTF from the content of metadata. The application should also print metadata records using a print friendly layout.

The tool should provide support for reuse and linkage of contact details. Normally contact details should be entered once, and re-used for all subsequent edits. This enables duplication of existing records for use as a first draft of a new metadata record.

The tool should also be linked to the spatial application to be able to update the metadata when any change occurs to the spatial data. This significantly can reduce redundancies in the metadata database. More importantly the reliability of metadata linked to spatial data will increase. An integrated approach for handling metadata and spatial data together will require an integrated data model and integrated application.

The ability to search for records using spatial, free text, keyword and other search terms through a simple or advanced search will increase the usability of the tool. The integrated help facility should also be available through the tool with table of contents, search facility and links to related web documents or websites, and a context help linking each of the elements to a summary and the detailed text of relevant sections of the user guidelines.

Finally in a MET, the metadata administrator should be able to generate reports, statistical data based on specific metadata (elements), agency inputs, exports, and searches. Table 1 summarises the criteria developed for the assessment of metadata entry tools.

3. METADATA ENTRY TOOL ASSESSMENT

A three stage methodology of assessment has been developed for evaluating a selection of metadata tools against the developed criteria. Figure 1 illustrates process flow and stages of the methodology.

Stage 1
In this stage, a collection of related documents about the tools have been reviewed and explored. This stage helped with understanding of background and objectives of the tools development. The criteria developed above were finetuned in accordance with the overall purpose of the tools.

Stage 2
In parallel to stage 1, the selected metadata entry tools were installed and the deployment process of each tool was investigated. Based on the results of the first stage, a questionnaire was developed and designed to be used by a number of five clients testing the user friendliness of each tool. The clients were selected from different background related to spatial science.

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Table 1: Selection criteria for Metadata Entry Tools.

Category	Criteria
Technical	Web based development technology
	Database technology and access
	Robust Code
	Easy Deployment
	Open source or Freeware software
Standards	Standard 1
	Standard 2
	Standard n
User Interface	Similarity to common software
	Intuitive navigation logic
	Intuitive interface enabling easy creation and editing of metadata records
Functionalities	Contact reuse
	Record duplication
	Automatic and integrated update
	Search tools
	Edit tools
	Import and export tools
	Format Conversion
	Print Friendly layout
	Help facility

Stage 3
Having developed the assessment criteria, the stage 3 was dedicated for evaluating the selected tools. Functionality available, technical requirements and the tools user friendliness were explored.
This section introduces the three metadata entry tools that have been studied and evaluated against the developed criteria. Each of these tools is explored in detail in this section, including background information essential to effectively assessing each of the tools in relation to the overall objectives of the article.

3.1 IDEC MetaD

The Infraestructura de Dades Espacials de Catalunya (IDEC) project is a common initiative of the Cartographic Institute of Catalonia (ICC), the Department of Territorial policy and public works, the Secretariat for Telecommunications and Information Society, and the Department of Universities, Research and Information Society of the Generalitat de Catalunya, within the framework of the III Research Plan 2001-2004 and the Strategic Plan for the Information Society (Catalonia on the Network). Its aim is to create a Spatial Data Infrastructure for Catalunya (MetaD, 2007).

Within IDEC initiatives, MetaD allows for the creation, edition and consultation of metadata stored in a data base. This includes the creation of new metadata records, as well as the maintenance of records already created. The tool incorporates various functionalities including an XML viewer. XML Viewer is a tool that allows the display of XML

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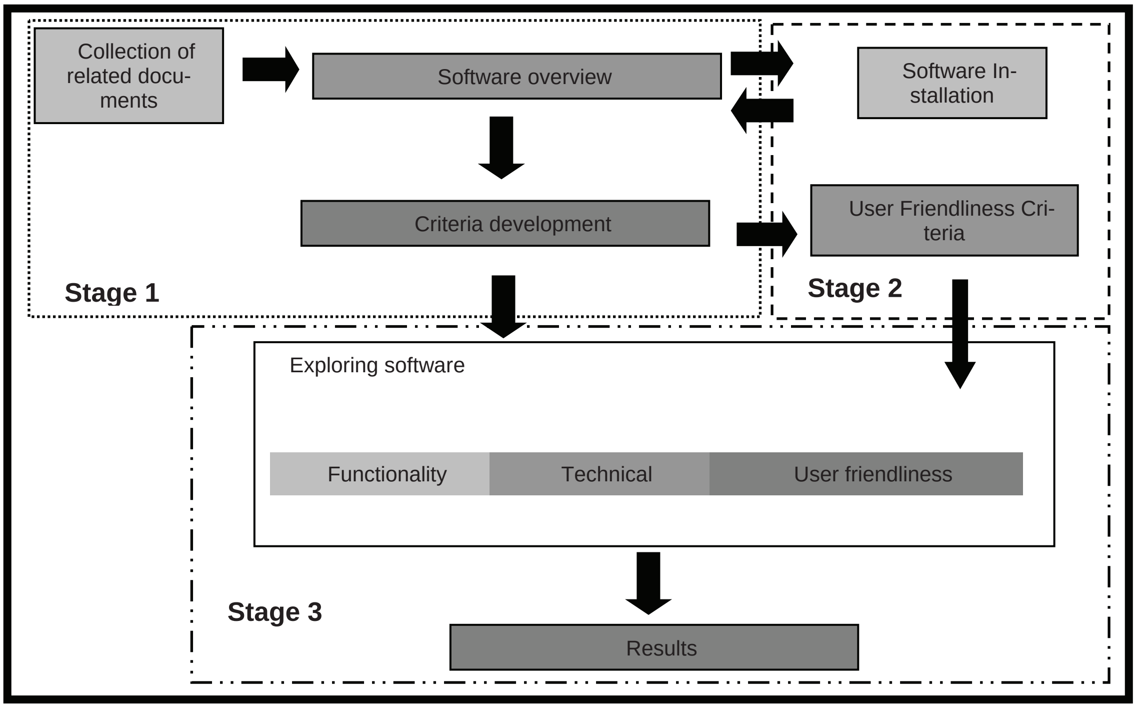
Figure 1: Metadata Entry Tools evaluation methodology.



files generated by other programs. The application also facilitates the incorporation and maintenance of thesauri of subjects and key words, with the purpose of facilitating the edition of metadata. This includes the ability to incorporate a users own list of key words. The software also allows the user to incorporate and exchange metadata with other organisations or departments stored within other data bases.

MetaD has been developed with visual basic (VB) programming language, which limits the ability of this tool to be developed for web based applications. However, MetaD has the ability to be connected to a database in the network.
MetaD uses Microsoft Access as the database technology. Access is used by small businesses create ad hoc customised desktop systems for handling the creation and manipulation of data. Some professional application developers use Access for rapid application development, especially for the creation of prototypes and standalone applications that serve as tools for on-the-road salesmen. Access does not scale well if data access is via a network, so applications that are used by more than a handful of people tend to rely on Client-Server based solutions.

The structure and terminology of this tool follows the Standard ISO 19115. As this standard is very generic, the IDEC has adapted it to the particularities of Spain, giving as result the elements that appear in the application.

In summary, the MetaD application uses a graphical style interface, in order to simplify the complexity of the metadata standard for users of the application. The application also has the ability to convert coordinates into other formats which are required for specific standards.

The objectives of the application are not just the ability to create metadata records for geographic information, but also to be able to easily maintain or change metadata re-

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cords as required. The application allows users to change former metadata records created. Once created, metadata can be exported to catalogues as XML files, either as single record sheets, or the entire file. Table 2 summarises the tool against the criteria developed.

Table 2: MET assessment result for MetaD.

Category	Criteria	
Technical	Web based development technology	No
	Database technology and access	Yes
	Robust Code	Yes
	Easy Deployment	Yes
	Open source or Freeware software	Yes
Standards	ISO 19115 support	Yes
	ISO 19139 compliant XML metadata	Yes
User Interface	Similarity to common software	Yes
	Intuitive navigation logic	Yes
	Intuitive interface enabling easy creation and editing of metadata	Yes
Functionalities	Contact reuse	Yes
	Record duplication	Yes
	Automatic and Integrated Update	No
	Search tools	Yes
	Edit tools	Yes
	Import and export tools	Yes
	Format Conversion	Yes
	Print Friendly layout	No
	Help facility	Yes
	Multi level access	Yes

3.2 CatMdEdit

CatMDEdit is a metadata editor tool that facilitates the documentation of resources, with special focus on the description of geographic information resources. CatMDEdit has been developed by the TeIDE consortium. TeIDE is a Spanish consortium constituted by the R&D groups of the University of Zaragoza, the Universitat Jaume I, and the Polytechnic University of Madrid.

The CatMDEdit library is freeware; it can be redistributed and/or modified under the terms of the GNU Lesser General Public License as published by the Free Software Foundation; either the current version of the License, or any later version.

The tool has been implemented in Java and is multi-platform (Windows, Unix). As it has been developed in Java and the storage of metadata records is managed directly through the file system, the application can be deployed in any platform with the minimum requirement of having Java installed.

CatMdEdit enables users to create consistent metadata describing spatial data resources. The functionality includes basic services for creating and editing metadata, as

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well as more enhanced tools to improve the quality of metadata, including the thesaurus management tool and a metadata automatic generation tool. The thesaurus tool facilitates mapping between a selected vocabulary and a large collection of datasets.

The automatic metadata generation tool is able to derive metadata from data sources by means of interconnection with commercial GIS tools or proprietary software. Examples of derived metadata are information about spatial reference systems, number and type of geographic features, extension covered by a dataset, or information about the entities and attributes of alphanumerical related data (Ballari et al., 2006).

The basic functionality works with any relational database management system, such as MS Access, Oracle, mySQL, which is responsible for the storage of the metadata entries using a SQL-92 metadata database model. The more advanced functionality is oriented to more advanced metadata contributors, as well as to catalogue administrators in charge of management and improvement of metadata controlled under the geographic catalogue. In this case, the system works with Oracle 8i because of its special capacities for the use of spatial objects, text management and thesaurus (Ballari et al., 2006).

CatMDEdit metadata edition is in conformance with the "ISO 19115. Geographic Information-Metadata" standard. Four interfaces are provided for the edition of metadata records:

1. A detailed interface following the ISO 19115 comprehensive profile.

2. A reduced interface following the *Ncleo Espanol de Metadatos* (NEM). NEM, a subset of ISO 19115, is a recommendation under development which has been defined by the Spanish National Geographical High Board (*Consejo Superior Geografico*). This subset includes all the elements defined for the ISO19115 Core metadata profile (‘Core metadata for geographic datasets’).

3. An interface following the SDIGER - INSPIRE metadata profile, which has been developed under the framework of the SDIGER project. This profile is based on the international standard ISO 19115 that was customised to meet the requirements set up in the proposal for a Directive of the European Parliament and of the Council establishing an infrastructure for spatial information in the European Community (INSPIRE).

4. An interface following the SDIGER - WFD metadata profile, which has been developed under the framework of the SDIGER project. This profile is based on the international standard ISO 19115 customised to follow the guidelines for metadata to implement the GIS Elements of the Water Framework Directive.

CatMDEdit metadata edition is also in conformance with the SDIGER - Dublin Core Metadata Application Profile for geographical data mining, which has been developed under the framework of the SDIGER project. This profile is based on the Dublin Core Spatial Application Profile developed by the European Standardisation Committee to improve the discovery of geographic information.

CatMDEdit permits the reuse of contact information (e.g., name, address, telephone …) of organisations and individuals, which must be filled in several metadata elements. The contact information about a responsible party is inserted only once and used whenever it is required. It also permits creation of an identical copy of the selected

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element in the metadata record. This tool allows making all common edit operations on the record selection window or on any other metadata edition sub-window. Apart from edit, save, cancel and refresh operations, it also adds operations to treat rows in windows that contain multi-valued table-represented elements. These tables appear both in the record selection window and in the metadata edition windows that contain several occurrences of a metadata element.

CatMDEdit supports exchange of metadata records according to different standards and formats. It also permits import and export of ISO 19115 metadata in XML format in compliance with ISO19139 technical specification. Additionally, there is interoperability with other metadata standards apart from ISO19115. The application allows input and output XML files in conformance with the standards CSDGM (Content Standard for Digital Geospatial Metadata, defined by U.S. FGDC), Qualified Dublin Core, SDIGER - Dublin Core Metadata Application Profile for geographical data mining, or MIGRA (Spanish standard for geographic information exchange). Table 3 summarises the tool against the criteria developed.

Table 3: MET assessment result for CatMDEdit.

Category	Criteria	
Technical	Web based development technology	Yes
	Database technology and access	Yes
	Robust Code	Yes
	Easy Deployment	Yes
	Open source or Freeware software	Yes
Standards	ISO 19115 support	Yes
	ISO 19139 compliant XML metadata	Yes
	SDIGER- INSPIRE and WFD	Yes
	SDIGER- Dublin Core	Yes
User Interface	Similarity to common software	Yes
	Intuitive navigation logic	Yes
	Intuitive interface enabling easy creation and editing of metadata records	Yes
Functionalities	Contact reuse	Yes
	Automatic Update	No
	Record duplication	Yes
	Search tools	Yes
	Edit tools	Yes
	Import and export tools	Yes
	Format Conversion	Yes
	Print Friendly layout	No
	Help facility	Yes
	Multi level access	No

3.3 Geonetwork

GeoNetwork open source is a standard based, Free and Open Source catalogue application to manage spatially reference resources through the web, designed to enable

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access to geo-referenced databases, cartographic products and related metadata from a variety of sources (Geonetwork Community, 2007).

The development of GeoNetwork has been undertaken by the Food and Agricultural Organisation (FAO) on the United Nations. It is beginning to attract attention with its adoption by a number of international programs, countries and regional SDI initiatives, including in the USA, France, Czech Republic and Hungary.

GeoNetwork opensource is a standardised and decentralised spatial data management environment, designed to enable access to geo-referenced databases, cartographic products and related metadata from a variety of sources, enhancing the spatial data exchange and sharing between organisations and their audience, using the capacities of the internet.

GeoNetwork comes with an internal DBMS server, the McKoi SQL database. For more than one connection to the same database, Mckoi SQL Database is a multi-threaded multi-user server. Mckoi SQL Database is an SQL Database written entirely in Java.

GeoNetwork opensource has been developed to connect spatial data communities and their data using a modern architecture, which is at the same time powerful and low cost, based on the principles of Free and Open Source Software (FOSS) and International and Open Standards for services and protocols (from ISO/TC211 and OGC). It supports metadata creation based on the ISO19115, FGDC and Dublin Core standards.

For contact reuse and record duplication, a template can be fully customised online and can be pre-filled with repetitive content (contact information for example). Geonetwork benefits from a search index capable of handling large amounts of metadata. The indexing is build using Jakarta Lucene. The full sets of query parameters used to search the GeoNetwork catalog are also available for harvesting jobs. It provides a uniform way of searching through the metadata.

Geonetwork provides a method storing and indexing of metadata in its original format. It also provides editing the different metadata standards online in default, advanced and XML mode. It is also possible access to the full set of ISO19115 and FGDC metadata elements through the generic online editor Geonetwork also has a Metadata Template system. This system allows to quickly creating new metadata entries. A template can be fully customised online and can be pre-filled with repetitive content (contact information for example). Templates can also be searched in the same way normal metadata is searched. But only editors and administrators have access to templates. Further, more templates can be created for specific user groups.

Geonetwork permits import of XML formatted metadata and possible conversion of the input file through XSL transformation. It also supports batch import of XML formatted metadata and possible conversion of the input files through XSL transformation. Table 4 summarises the assessment result for Geonetwork.

3.4 Assessment result

During the assessment, the aim was to observe clients using the products in an as realistic a situation as possible, to discover the effectiveness of the assessment methodology. The development of metadata applications not only should focus on technical capabilities of the tool, but also it should concentrate on usability and functionality of

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Table 4: Assessment result for Geonetwork.

Category	Criteria	
Technical	Web based development technology	Yes
	Database technology and access	Yes
	Robust Code	Yes
	Easy Deployment	Yes
	Open source or Freeware software	Yes
Standards	ISO 19115 support	Yes
	ISO 19139 compliant XML metadata	Yes
	Dublin Core	Yes
User Interface	Similarity to common software	Yes
	Intuitive navigation logic	Yes
	Intuitive interface enabling easy creation and editing of metadata records	Yes
Functionalities	Contact reuse	Yes
	Automatic Update	No
	Record duplication	Yes
	Search tools	Yes
	Edit tools	Yes
	Import and export tools	Yes
	Format Conversion	Yes
	Print Friendly layout	No
	Help facility	Yes
	Multi level access	Yes

the functions. This is often caused by pressure to develop systems based on technicians' expectations instead of overall non-professionals' needs.

For instance, overall observation of five clients with MetaD user interface showed the tool was simply understood with them. The clients did not have too many difficulties with understanding instructions, manipulating parts, or interpreting functionalities. Another example was the user interface testing with CatMEdit, which did not uncover difficulties with learning operating and navigating in software for five clients and entering and editing metadata was a simple process, but it still seemed that CatMEdit needed improvement.

With a large community supporting development of Geonetwork, clients can easily find information and assistance if needed. Geonetwork opensource enjoyed a user friendly interface to search and manage Metadata. A comprehensive metadata editor also supported its popularity among the five clients. The web based catalogue application and the integrated InterMap interactive map client application made it very attractive for clients. The tool is easy to learn and operate.

As illustrated in Tables 2, 3 and 4, none of the tools has an integrated approach to handle spatial data and metadata together in a seamless database. Integration of

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metadata and spatial data is new and enables the spatial data to carry their own metadata description with them. The next section discusses the significance of an integrated method for managing spatial data and its metadata together.

4. METADATA INTEGRATION-SIGNIFICANCE AND INNOVATION

The research in metadata integration should focus on utilise metadata standards and developments in order to combine metadata and spatial data within an integrated package, so that the process of updating or creating spatial data and metadata – where feasible – becomes one process rather than two.

This approach distinguishes between already existing spatial data models, which have to be extended. If common metadata-spatial data sets exist, the concept of views allows metadata and spatial data to be extracted according to various standards and published in an OGC compliant registry. This aligns with the OGC Open Services Framework which is based on a publish-find-bind architecture. This creates flexibility and interoperability. Tools developed to both integrate spatial data and metadata and to automate the process of updating metadata would be used widely within the spatial data sector.

Some elements of metadata obviously cannot be automatically updated. These would not be stored in an integrated fashion with the spatial data. Only those metadata elements that can be automatically updated would be integrated with the spatial data. This will save producers of data both time and money associated with the updating of metadata records, and will also aid data users who require up to date metadata to be delivered with data for their use.

Research undertaken within ETH Zurich University in conjunction has examined the possibilities of integrating metadata and spatial data and creating an automated process (Najar et al., 2007). This initial research lays the ground work for the development of appropriate metadata management tools, applications and models which will directly aid the development of the integrated approach for managing and automatic updating spatial metadata.

5. CONCLUSION

Many national and international issues concerned with land management, environmental sustainability, water and disaster management can be addressed by having the ability to find and access high quality spatial data within SDIs. The ability to find and access the appropriate information relies on having up-to-date metadata. However, current metadata models, application and standards are complex and very difficult to handle, often with missing or incomplete metadata. It is also viewed as an overhead and extra cost by organisations.

The key criteria for supporting flexible metadata applications are those of technical requirement, compliance with international standards, user friendly interface and availability of necessary functions for handling metadata records. Ensuring proper development technology together with efficient database technology to support access and maintain metadata records have been identified as critical factors within the technical criteria. Meanwhile, robust coded open source METs will be more efficient as the metadata standards evolve. Consequently, a metadata entry tool must be sufficiently flexible to address the changes to metadata standards over time and to allow users to create and extend a standard to satisfy organisational and local needs. Finally, the

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MET designers should focus greatly on creating designs that satisfy the user requirements in terms of functionality and usability. A tool primary function should be more than handling the different standards, rather making maintenance of the metadata records easy for the user.

More importantly, the ability to automatically generate metadata relating to spatial data, and make it available through SDI will have important benefits all practitioners including spatial data producers, vendors, distributor and user. One of the easiest ways in which to investigate and search for spatial data is through integrated metadata directories. If users can find data and services, then they will be utilised, growing the spatial data market. This highlights the importance of the integrated tools to businesses and agencies that produce spatial data. Data producers can cut down on the amount of time and money spent producing metadata, while at the same time increasing the ability for customers to find and hence use their data and services. This will enable metadata to be maintained dynamically in a way that addresses the more real-time requirements of people and organisations that use spatial data.

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