Standards are the Bones of an SDI, but Where's the Beef?

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Abstract. Much progress has been made in the global interoperability of computing technologies and software application development from the vendor's point of view, due to growing adherence to formal and de facto standards. The purpose of any standard is to assure the users of standards-based computer solutions that they will find no surprises. Instead, users should experience full convergence between the expected, declared and actually displayed system's characteristics.

The vendor's opportunity is to approach standards compliance from the user's point of view. How can we design products that allow users to complete their workflows reliably and easily, and so that adherence to important standards enhances those workflows and does not introduce technical hurdles? This presentation will provide an overview of Intergraph's product development methodology and the areas in which standards compliance guides the planning of user workflows.

Keywords: geospatial standards, OGC, INSPIRE, interoperability, spatial data infrastructures (SDI)

1. Introduction

Vendors of geospatial software solutions comply with OGC® interoperability standards so that customers will have no surprises when using products featuring OGC interfaces with compliant products offered by other vendors. They rely on ISO standards for a range of definitions and schema, stretching from the lengthy and complex down to standardized code lists. They may also wish to sell solutions to European data producers who must comply with INSPIRE specifications so that users of their data will have no surprises when it is exchanged, integrated, and used across the EU community.

Ideally all the personae – vendors, data producers, and data consumers -- should all be able to bank on such interoperability, just as we presume that electrical current flows without our attention from wall sockets around the globe into our mobile devices, no matter what the country, no matter what brand the device.

But users of standardized products, services, and data may be surprised to find that standards only provide the most essential elements of compatibility. They may be unnerved by technical standards jargon, and they may be challenged to make implementation choices they had assumed the standard would take care of. They may be frustrated, or even find themselves dependent on "value-added" services from a consultant or software vendor who they must trust to guide the implementation and use of the solutions selected.

Sadly, standards provide little more than a low common denominator across products, leaving much to the choices made by solutions designers and implementers. Returning to the electricity metaphor: though we can obtain power from wall sockets all around the world, when moving between countries we often need to have power adapters to connect our mobile devices due to the sockets' diversity.

The vendor's opportunity is to approach standards compliance from the user's point of view by understanding the important business workflows that the user wants to accomplish. How can we design products that allow users to complete their workflows reliably and easily, and so that adherence to important standards enhances those workflows and does not introduce technical hurdles? How can we help users accomplish what they REALLY need and want to do in a way that provides transparent standards compliance? Intergraph strives to answer these questions by offering solutions that go above and beyond the call of standards, and provide high-quality, value-added solutions.

This paper will provide an overview of Intergraph's product development methodology and the areas in which standards compliance guides the planning of user workflows. We will provide examples of creative functionality built into our solutions, and examples of how our solutions offer more than simple standards compliance, while insulating users from their technical complexities.

2. Customers and Standards

Intergraph's vision is "to help organizations see the world clearly[1]". Two of Intergraph's core values are that we are "innovative" and we are "customer-focused."

- We understand the importance of innovation in meeting the ever-changing needs of our customers. . .; and
- We know our customers' success . . . is based on our ability to talk openly and set clear targets to meet their needs.

Starting from these values, how does Intergraph see standards fitting with the changing needs of customer?

2.1. Our Development Process

In 2010 management of Intergraph's SG&I (Security, Government and Infrastructure) division determined to adopt a new set of software development methods. They determined that moving to an Agile / Scrum software

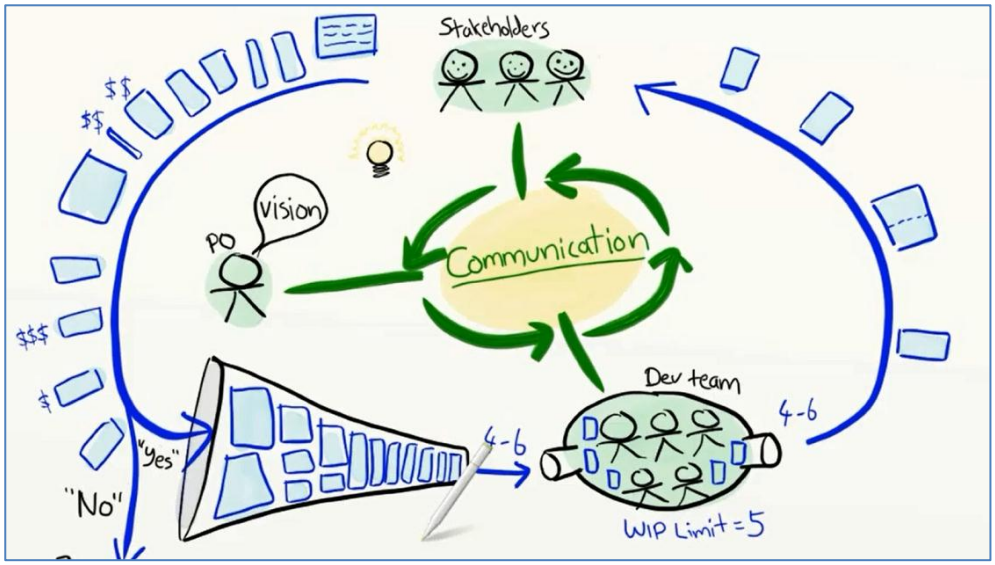

Figure 1 - Intergraph SG&I Agile/Scrum develoment methodology

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[1] Intergraph is part of Hexagon, a leading global provider of design, measurement, and visualization technologies that enable customers to design, measure and position objects, and process and present data. See http://www.intergraph.com/about_us/vision.aspx for more details.

development methodology was likely to improve customer satisfaction and trust by delivering business value.

SG&I management focused on five goals, including project oversight which would assure timely resolution of customer-identified issues and road-blocks, and establish flexibility and responsiveness to meet market trends and customer needs.

Figure 1 provides an informal view of a development process in which customers – characterized as "stakeholders" -- play a primary role in defining exactly what development efforts will provide the greatest customer value.

Development teams commit to their stakeholders that they will address specific goals and provide defined deliverables each month. The results of each development "sprint" are valuable and "potentially deliverable" to stakeholders. Stakeholders are provided with deliverable software as part of our review process so they can test functionality and usability with "real world" datasets.

Actual product releases are delivered to stakeholders – with tested install-ware and mature documentation – as often as quarterly and no less than annually. Intergraph believes that standards adherence gives our software the basis of its value to customers – that is: the "bones," and that our development methodology – continuous focus on stakeholder value – provides the "beef" for our products.

During a project the customers can change their minds about what they want and need on the basis of progress they actually see (often called requirements churn). Intergraph believes that the customer's need or problem cannot be fully understood or defined without iterations, so we focus on maximizing the team's ability to deliver quickly and respond to emerging requirements. When addressing requirements for standards compliance Intergraph recognizes that the most important questions are not focused on the technicalities of the standard itself. Rather, we use sprint iterations to understand from customers how we can make their interaction with the technicalities of the standards as transparent as possible, easy to use, and robust.

2.2. Requirements and Standards

Intergraph learns about actual customer requirements by inviting them to be active stakeholders and to participate in periodic review sessions, by analyzing data on customer problems and "wish lists," by outreach to customer proxies, and by reviewing requirements listed in competitive bid documents – whether or not an Intergraph procurement results.

Experience shows that standards-compliance is highly relevant to many customers, and can constitute non-negotiable solution requirements.

1. Many customers deploy solutions from other vendors and want to know that Intergraph solutions will inter-operate with those from third parties. Standards, rather than company-specific or product specific solutions, are the most transparent and lowest-risk means to address specific requirements with multi-vendor solutions.
2. Customers must often conform to mandates for standards compliance laid down by legal authorities or government funding sources.
3. Some customers want to deploy standards-based products because they feel that in the longer term adherence to open standards is the "right thing to do."[2]

Without careful analysis customers may not be able to ascertain whether vendor solutions are standards-compliant. Nonetheless, such compliance is so central to the requirements of many customers that vendors need to know a great deal about what customers expect, be able to advertise and demonstrate compliance with the expected standards, and be able to deliver a solution that is actually compliant.

2.3. What Standards are Considered?

At its highest level of generality (according to Wikipedia) a **standard** is "Any norm, convention or requirement." To refine this just a bit:

1. Some standardization documents may be called by their authors and users as "specifications," "rules" or other terms. This discussion encompasses these as well.
2. This discussion is confined to those standards which are written documents that can be viewed, critiqued and implemented,
3. Standards may emerge from widely-followed norms; these are "de facto." This discussion is confined to "de jure" standards, developed and adopted through some organization and due process.

All computer operations and software depend upon layers of lower-level standards relating to electronics and computer science. Confining this discussion specifically to standards which relate to digital geographic infor-

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[2] Some of the attributes of ideal standards, as compiled by the W3C, include "Maintainability, modularity, minimum redundancy, accessibility, device-independency, internationality, extensibility, learnability, readability, efficiency, implementability, simplicity, longevity, backwards compatibility, interoperability, and stability".

mation/informatics, we recognize three major global organizations whose works are important. The following table provides an overview of their domains of their several standardization activities.

European Commission – Infrastructure for Spatial Information in the European Community (**INSPIRE**)	INSPIRE standards are technical documents that ensure that the spatial data infrastructures of the Member States are compatible and usable in a Community and transboundary context."
International Organization for Standardization – TC211 (**ISO**)	ISO standards are technical documents that detail 'methods, tools and services for data management".
Open Geospatial Consortium® (**OGC**)	OGC standards are technical documents that detail "interfaces or encodings".

Table 1. Domains of three standards organizations (Source: Organizational web sites cited at "References").

Each of these organizations develops, revises and publishes standards of great potential interest to vendors of geospatial applications and to our customers. Some examples referenced in this paper are listed in the following table.

Organization & Standard	Summary Scope of the Standard
INSPIRE -- Technical Guidance for the implementation of INSPIRE Discovery Services, v3.1	"Specifies Technical Guidance for Member States to implement INSPIRE Discovery Services as mandated by the Regulation on INSPIRE Network Services."
ISO -- ISO/TS 19139:2007 -- Geographic information -- Metadata -- XML schema implementation	"Defines Geographic MetaData XML (gmd) encoding, an XML Schema implementation derived from ISO 19115."
OGC ® -- OpenGIS Catalogue Service Implementation Specification v2.0.2 – OGC-07-006r1	"Identifies the interfaces, bindings, and a framework for defining application profiles required to publish and access digital catalogues of metadata for geospatial data, services, and related resource information."

Table 2. Examples of standards (Source: Organizational web sites cited at "References").

A more complete list of standards relevant to organizations participating in Spatial Data Infrastructure (SDI) projects can be found in Annex A.

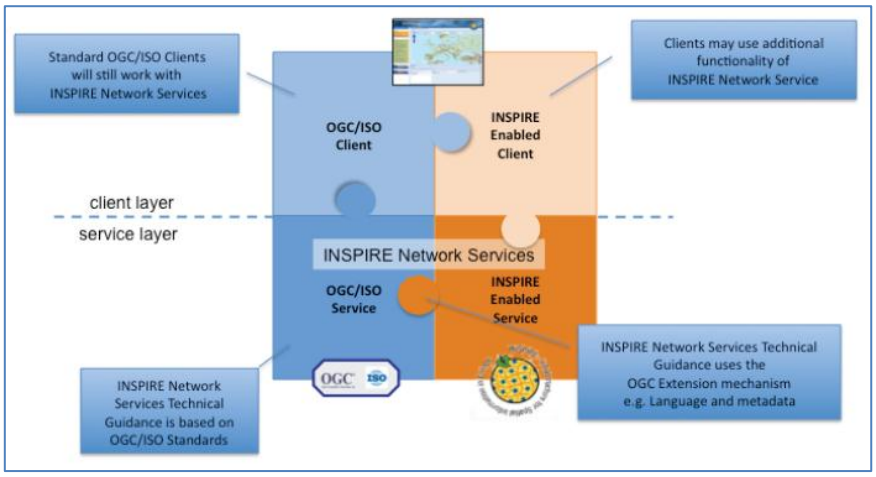


Figure 2 -- Extending ISO and OGC Standards for INSPIRE Requirements (Source: Technical Guidance for the implementation of INSPIRE Discovery Services Version 3.1, p.8); hereafter referenced as „Tech.Guide“.

Figure 2 illustrates the inherent interdependence of many standards; i.e., planning compliance with one may entail learning about and conforming to other standards – not necessarily developed by the same authority, and not neatly embedded one within the other. Compliance with the standards reference in Figure 2 would be impossible if the relevant authorities did not observe domain boundaries and grant mutual recognition to their respective standards documents. Interdependencies create problems: organizations attempting to implement standards must comprehend multiple versions of standards documents authored by several authorities, through lifecycles that see standards move from “proposed” through “adopted” to “deprecated”.

3. Standards Compliance and More

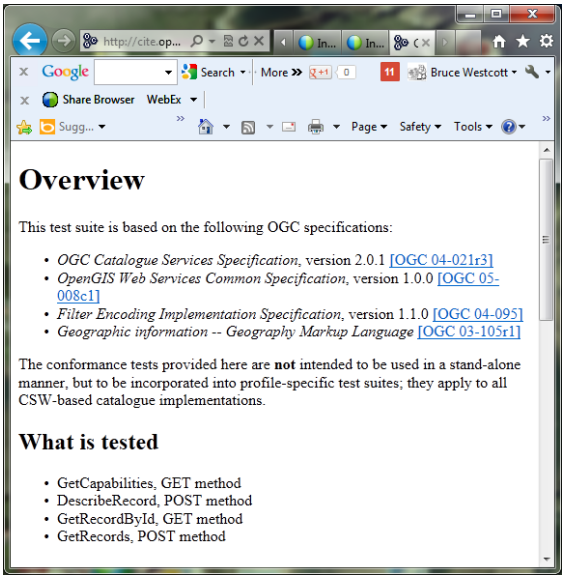
To repeat the central question addressed in this paper: *“How can Intergraph design products that allow users to complete their workflows reliably and easily, and so that adherence to important standards enhances those workflows and does not introduce technical hurdles?”*

Our answer is that the customer-focused development methodology described above results in four practices by which we strive to exceed the customers’ expectations about standards compliance.

3.1. Compliance through Testing/Certification

It is fundamental that Intergraph

- perform internal testing of software, and assure conformance with all available standards testing or certification programs, and
- demonstrate and advertise conformance for potential customers.



Overview

This test suite is based on the following OGC specifications:

- *OGC Catalogue Services Specification*, version 2.0.1 [OGC 04-021r3]
- *OpenGIS Web Services Common Specification*, version 1.0.0 [OGC 05-008c1]
- *Filter Encoding Implementation Specification*, version 1.1.0 [OGC 04-095]
- *Geographic information -- Geography Markup Language* [OGC 03-105r1]

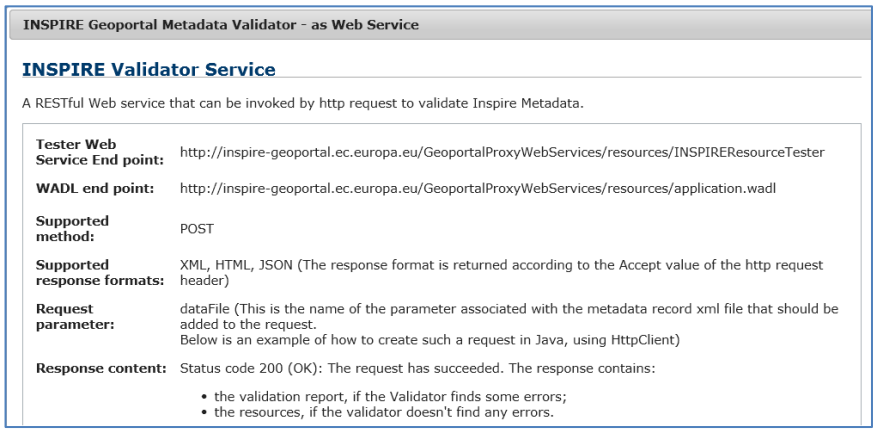
The conformance tests provided here are **not** intended to be used in a stand-alone manner, but to be incorporated into profile-specific test suites; they apply to all CSW-based catalogue implementations.

What is tested

- GetCapabilities, GET method
- DescribeRecord, POST method
- GetRecordById, GET method
- GetRecords, POST method

Figure 3 -- Example of an OGC test suite

Intergraph makes ongoing efforts in this area, as the standards being certified may be advancing, and the relevant testing scripts and other automated procedures may evolve. Test procedures may include testing of the software, use of standard test data sets, or validation of the software outputs.



INSPIRE Geoportal Metadata Validator - as Web Service

INSPIRE Validator Service

A RESTful Web service that can be invoked by http request to validate Inspire Metadata.

Tester Web Service End point:	http://inspire-geoportal.ec.europa.eu/GeoportalProxyWebServices/resources/INSPIREResourceTester
WADL end point:	http://inspire-geoportal.ec.europa.eu/GeoportalProxyWebServices/resources/application.wadl
Supported method:	POST
Supported response formats:	XML, HTML, JSON (The response format is returned according to the Accept value of the http request header)
Request parameter:	dataFile (This is the name of the parameter associated with the metadata record xml file that should be added to the request. Below is an example of how to create such a request in Java, using HttpClient)
Response content:	Status code 200 (OK): The request has succeeded. The response contains: • the validation report, if the Validator finds some errors; • the resources, if the validator doesn't find any errors.

Figure 4 - Example of an INSPIRE validator service

Testing and validation may focus on the format and content of outputs, and – in the case of web services – service quality attributes such as reliability and responsiveness. Examples taken from INSPIRE documentation (cited in Table 2) include:

- *"The response time for sending the initial response to a Discovery service request shall be maximum 3 seconds in normal situation. [...] Normal situation represents periods out of peak load. It is set at 90% of the time."*

- *"The minimum number of served simultaneous requests to a discovery service according to the performance quality of service shall be 30 per second."*

Actual performance is the only means to judge compliance with such standards: Intergraph must set up services to be tested, test against the various quality-of-service criteria in varying environments, document results, and make them public.

Beyond providing, validating, and advertising technical compliance, Intergraph software design is based on the conviction that users should be spared the need for technical understanding and the workflow complexities that standards compliance can bring. The sections below provide some concepts behind our work, and samples of their implementation.

All these samples apply to workflows inherent in the "Discovery" use cases detailed in the INSPIRE literature. The following figure illustrates use cases for the creation and publication of metadata, their discovery through a discovery service and viewing of spatial data sets via an INSPIRE View service.

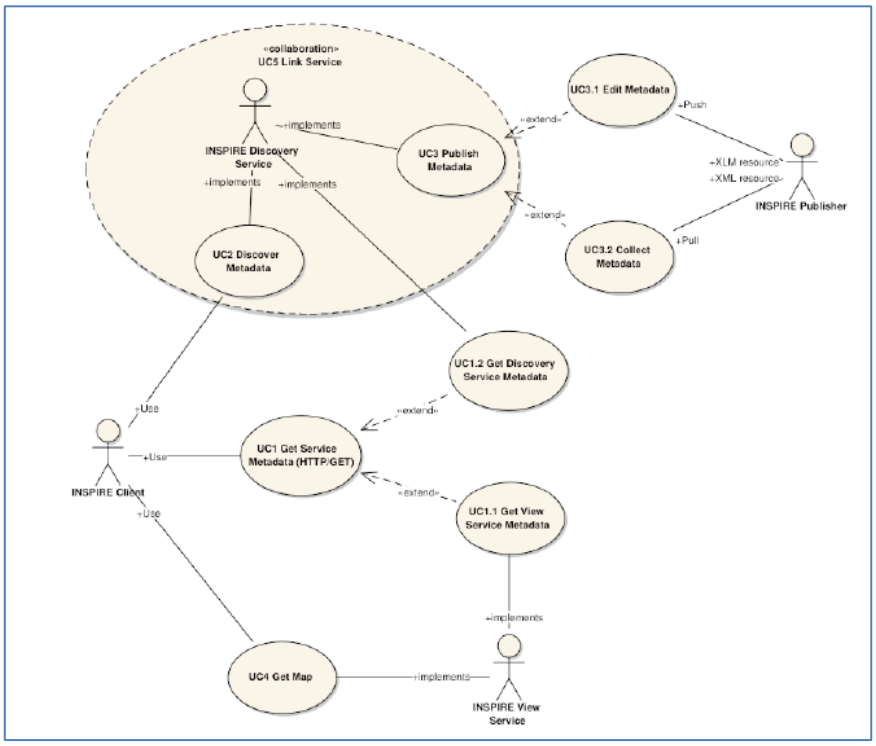


Figure 3 - INSPIRE Data Discovery use cases (Source: „Tech.Guide", p.12)

3.2. Providing Friendly and Flexible Data Display Formats

Users of geospatial applications may have workflows in which they need to view or search standards-compliant information; Intergraph's approach to supporting these workflows is simple. Whenever possible, we aim to give all our applications the capability to read and write data in common exchange formats, with the goal that customers can then select their application of choice for viewing. Users may be quite comfortable importing, formatting, viewing and manipulating information using common desktop productivity tools (e.g. databases and spreadsheets.) for filter and display of tabular data.

3.2.1. XML Stylesheeting

Another approach builds on the prevalence of XML as a common file format used in the expression and transfer of information. Of course XML format allows for searching and viewing using simple tools (e.g. no cost view/edit tools for TXT and XML, and even web browser clients). Intergraph provides styled views of XML files which conform to many standard schemas[3].

A simple example is the case in which a user wants to see information about a web service: Who provides the services, what sorts of data are served, and what are other details? Perhaps another user has recommended that you connect to the service offered by http://demo.geospatial.intergraph.com/csw , or you are using a web client which has connected to this service. Users knowledgeable about OGC services would issue a "GetCapabilities" request using the proper syntax in a web browser application, and the service would reply with XML containing all available information, as pictured in Figure 5.

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[3] XML files contain data content, along with "tags" and other syntactic elements. XSD files define the structure or patterns in which the content of standardized XML files is expressed. XSL files provide layout and formatting for the viewing of XML files.

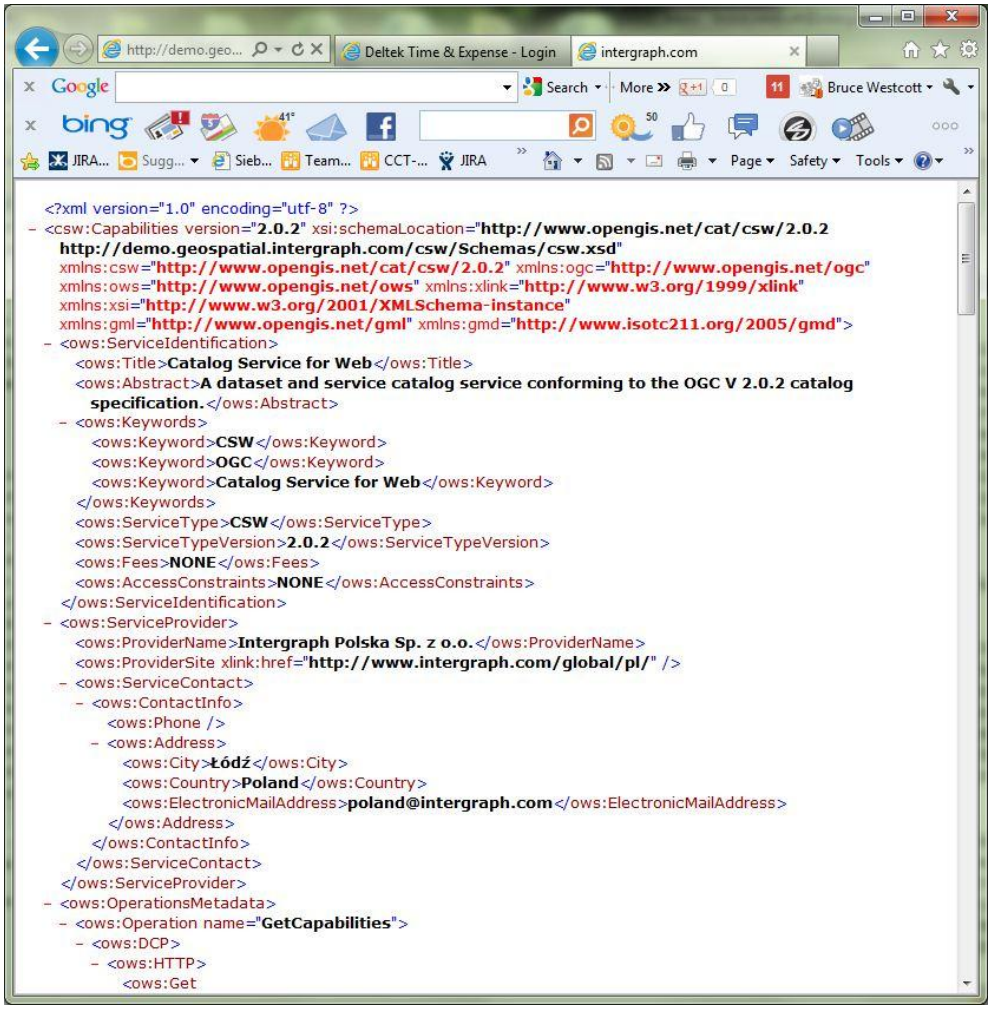

Figure 4 - "GetCapabilities" response

Because the XML conforms to a known schema (XSD), creation of a stylesheet file (XSL) is a straightforward development task; use of such a file renders the XML content easier to scan, view, or print. Intergraph-provided stylesheets can easily be modified by a licensed user to fit the visual style of the enterprise that provides the viewing platform. Figure 6 displays Intergraph's styling of such a "GetCapabilities" response.

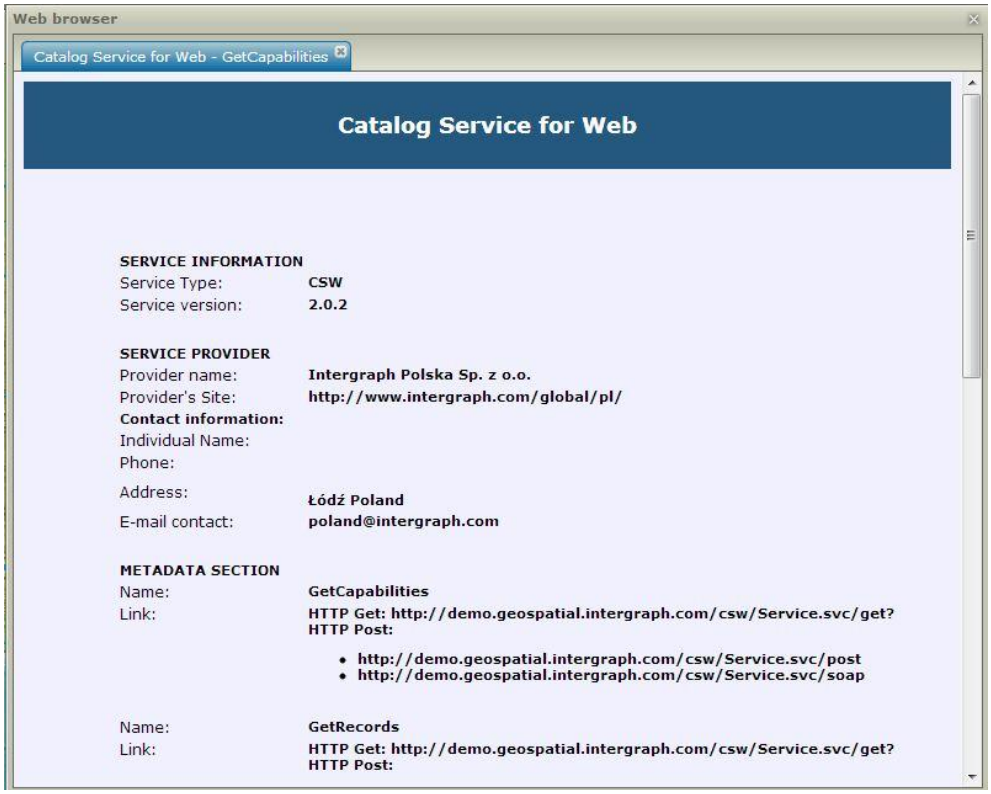

Figure 5 - Stylesheeted "Get Capabilities" response

3.2.2. Supporting Multi-Lingual Display & Data Entry

Because Intergraph has an international customer base, we utilize standard industry practices and advanced translation tools for generating software that can be installed in a selection of languages. INSPIRE standards (European Union) and numerous countries require multi-lingualism, and we address the needs of customers in those environments with two additional development practices.

First, Intergraph adheres to Microsoft standards and practices for globalizing and localizing our applications[4], supporting release on operating systems of all languages. We provide out-of-the-box localization for locales in

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[4] „Globalization is the process of designing and developing a software product that functions in multiple cultures/locales. Localization is the process of adapting a globalized application, which you have already processed for localizability, to a particular culture/locale." Source: Microsoft MSDN.

which there is high demand for specific products, and use an architecture and advanced tools that make further localization projects as efficient as possible. The following figure illustrates the ease by which a user can override the default language offered by an Intergraph portal.

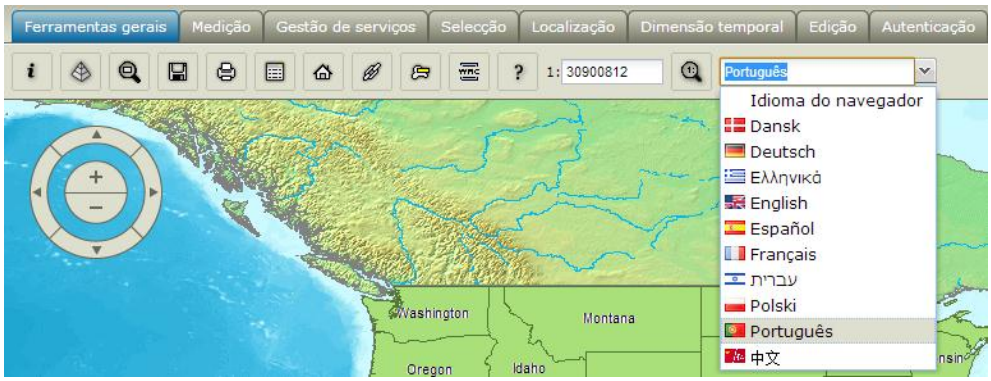

Figure 6 - User Language Selection in a localized web application

Second, when we can build our applications to utilize XML strings for initializing user interfaces, we provide administrators with opportunities to modify the code-lists, input tags, „help“ phrases, and other elements in different languages.

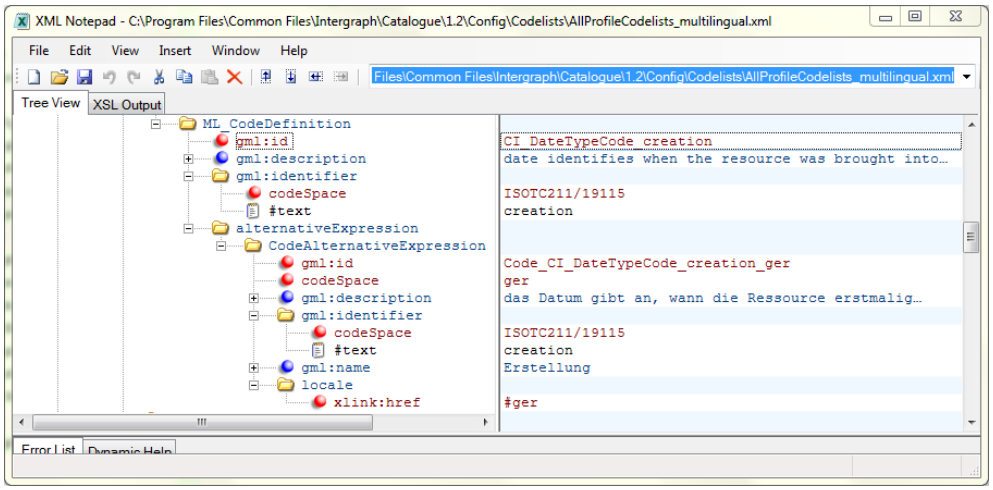

Figure 7 -- Standards-compliant codes expressed in multiple languages

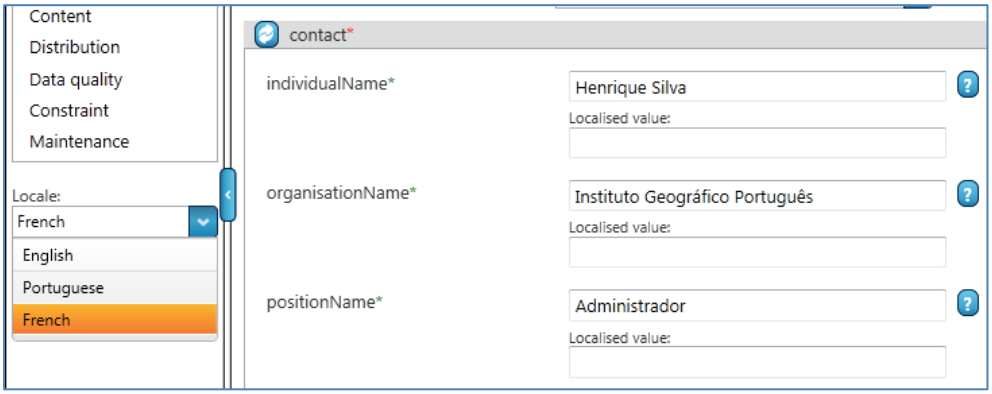

Figure 8 – Input of multiple localised values

Further, when standards compliance requires software to support multi-lingual data entry capabilities, Intergraph uses the flexibility inherent in XML to present a UI in the language based on the Windows user preference, and configurable to allow the user to select an alternate language and character set for data input, as illustrated by the figure above.

3.3. Assuring Compliance at Data Entry

Users of Intergraph software regularly follow workflows that require entry of data which conforms to standards governing content or format of different data elements. Standards often stipulate the data types of data elements to be entered, the length or format of string or other field types, or valid domains for codes. Some examples: telephone numbers and postal codes that vary in format by region or country, LAT/LON coordinates must fall within valid numeric ranges, and language or country codes must conform to ISO-defined code lists.

Whenever possible, Intergraph provides data entry interfaces similar to that pictured in the figure below which support the user in entering data elements that can be validated against relevant standards. Some techniques include:

1. Standardized naming of each element, including visual indicator for "Mandatory/Optional,"
2. "Hover Help" that includes the definition, format and a sample value for the element,
3. Element-level automatic error-messaging, highlighted visually and
4. Drop-down code lists.

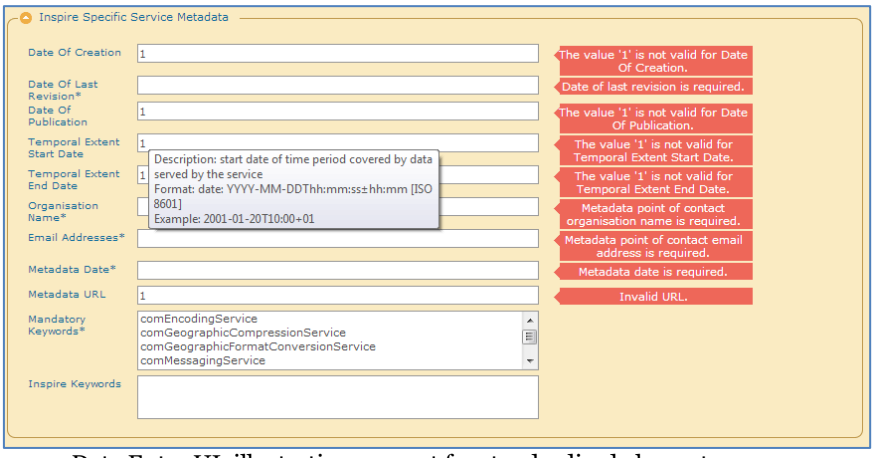

Figure 9 - Data Entry UI, illustrating support for standardized elements

3.4. Moving Beyond Mandatory Provisions

Important geospatial standards often prescribe a relatively sparse set of "mandatory" provisions, providing great flexibility for the user to implement "optional" provisions. As part of software design vendors must address three tasks. First, we must assure customers that all mandatory provisions of particular standards are addressed; second, we must give users the ability to adopt optional provisions – this may include providing them with procedures, templates, "wizard" software, etc. Third, we try to consider which "optional" provisions and features will be most attractive to a quorum of users, and build these into our products in ways that will not create added burdens for customers who choose not to utilize them.

Intergraph builds applications which include export and import capabilities; therefore, our customers expect that these applications will be sufficiently robust to use data produced by other users, generated by the applications of other vendors, with perhaps varying implementations of standards. Experience in this environment teaches, at best, vendor humility and collegiality, as we recognize that others will make choices about standards implementation that are not the same – and may not be immediately compatible with one's own choices.

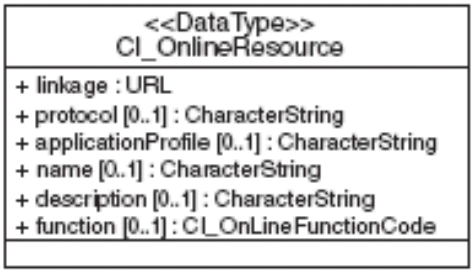

Figure 10 - R/O Online Resource attributes (Source: ISO-19115)

Similarly, Intergraph provides customers with both Web client and server applications, and therefore supports customer workflows that require connectivity and data exchange with client and server applications produced by other vendors.

At many points in an ISO metadata record, the author may wish to provide a locator for a web resource. As illustrated above, the author MUST supply only the URL itself. The protocol, application profile and other attributes are OPTIONAL, even though they may be important in helping the user of that metadata record actually make use of the resource. Similarly, everywhere the author might provide contact information in the metadata record, only the name is REQUIRED; it need not even be the name of a person. Any indication of the person's role or responsibility, let alone an email address or contact information is purely OPTIONAL.

For either of these examples, the provisions of ISO "profiling" allow not only for required and optional elements to be included in standardized metadata records, but also for the inclusion of elements defined by other ISO standards, and even for non-standardized "extended" elements known within a particular user community. As a consequence, Intergraph strives to support our customers with tools for modifying data creation, data storage and data processing logic to accommodate information well beyond that specified as MANDATORY.

3.5. Anticipating and implementing extended workflows

Customers typically wish to execute well-defined workflows efficiently, reliably, and repeatedly. Intergraph's goal is to facilitate that goal by integrating standardized data and services with high-value geoprocessing functions that we can provide. Web-based "open" geoprocessing workflows integrate data and services in an interoperable way, where it is necessary that each step of the workflow is responsible for only a specific task, without being aware of the general purpose of the workflow.

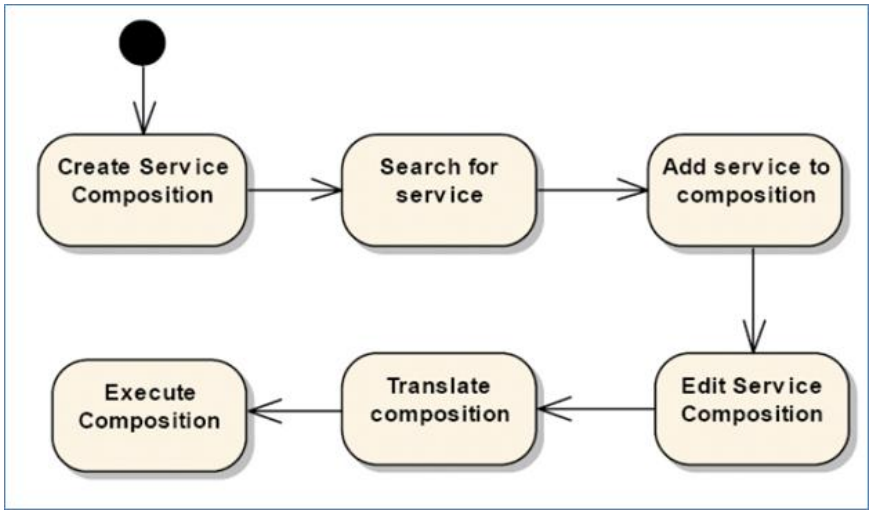

Figure 11 – Conceptual View: Geoprocessing Workflow steps (Source: OGC Reference Model)

Intergraph's goal is to provide customer with a web-based portal environment in which they can leverage connections to open services and support multiple user-defined, customized workflows.

The following figures illustrate such an environment, incorporating the discovery, viewing, analysis, (optional) download of features or images, and their deployment within other web-based mapping applications or proprietary desktop applications.

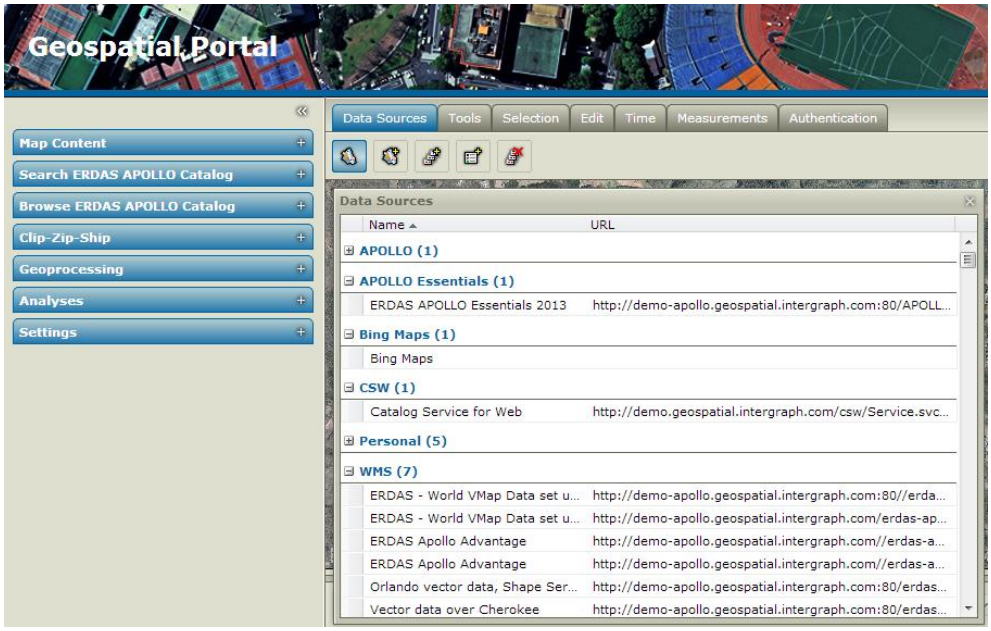

Figure 12 -- Portal connections to Services

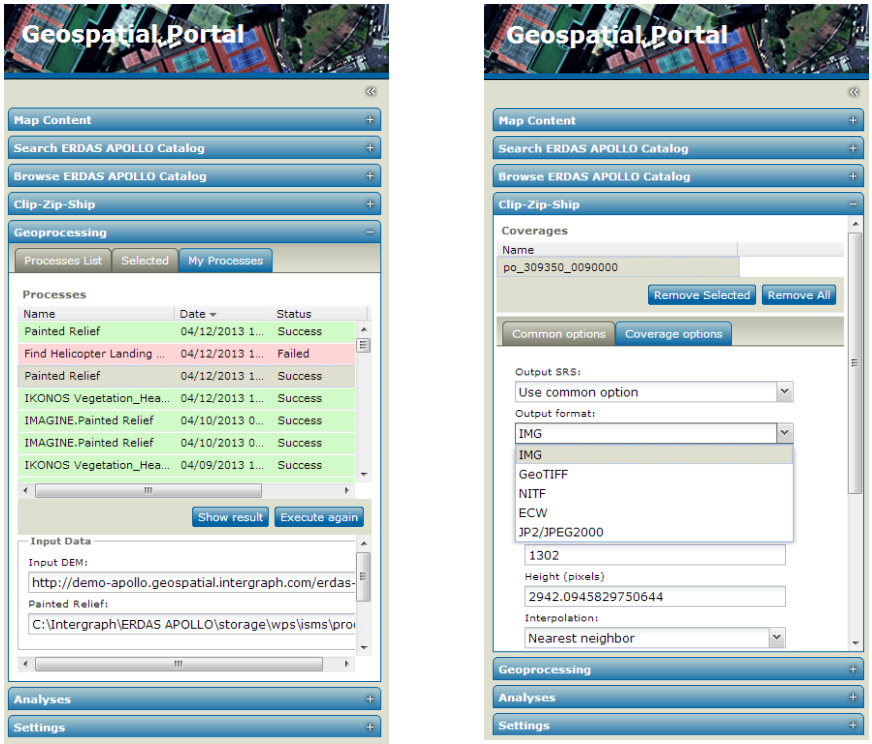

Figure 13 – Workflow steps -- geoprocessing and data extraction – following standards-based workflow steps – discovery and viewing

Standards prescribe the format and content by which map layers can be linked with the metadata which describes them, the web service connections that provide the layers, downloadable data sets in which the features or images are contained, and other properties which support different workflows. The following graphic illustrate optional back end steps to the workflow: downloading a file directly, adding it to a Zip file for emailing to the user, or opening directly in a web-based or desktop application.

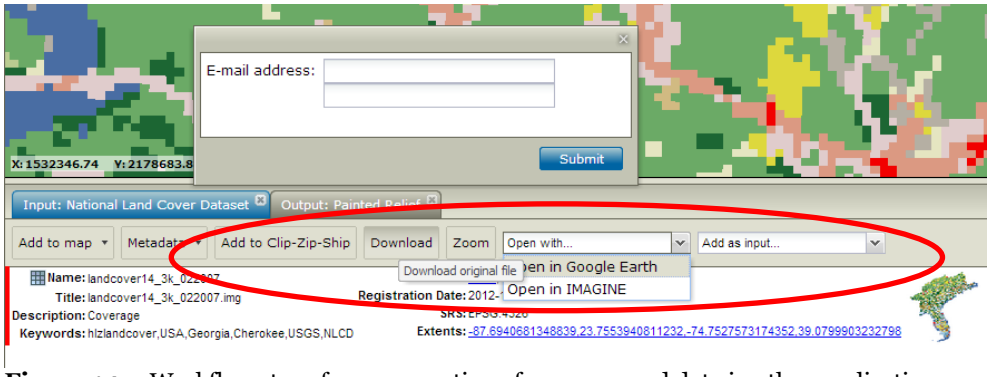

Figure 14 -- Workflow steps for consumption of geoprocessed data in other applications

Intergraph's customers tell us that they will buy applications which will support such multi-step, customizable workflows. As a matter of software design, Intergraph finds that reliance on standards as building blocks is not just the <u>most efficient and open</u> way to implement such workflows; rather, our adoption and extension of these standards is the <u>only</u> way to implement them.

4. Conclusion

In assuring compliance of our softare products with important global geomatics standards, Intergraph tries to start from the user's point of view. How can we design products that allow users to complete their workflows reliably and easily, and so that adherence to important standards enhances those workflows and does not introduce technical hurdles? In the few short years that the Internet has made our global markets seem much more interconnected, we have also seen great advances in the maturity, and comprehensiveness of relevant standards. With that maturity has come „openness," and consequent complexity of implementation.

Intergraph takes a leadership role in developing and implementing relevant standards. We provide our customers with tools and understanding of how they can implement Intergraph software, but most important of all – we

focus our development process on understanding their requirements and the workflows they trust our software to perform.

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Open Geospatial Consortium -- OGC® Compliance and Interoperability Testing Initiative (CITE). http://cite.opengeospatial.org/ and http://youtu.be/teL-ikra6FM

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Annex A -- Standards for Spatial Data Infrastructure

"Foundational" SDI Standards
W3C Recommendation: eXtensible Markup Language (XML) Version 1.1
W3C Recommendation: XML Schema Version 1.0
W3C Recommendation: Hyper Text Transport Protocol (HTTP) Version 1.1
W3C Recommendation: Simple Object Access Protocol (SOAP) Version 1.2
W3C Note: Web Services Description Language (WSDL), Version 1.1
Oil and Gas Producer (OGP, formerly EPSG) Geodetic Parameter Dataset, Version 6.9 (2006)
Geographic Tagged Image File Format (GeoTIFF) Version 1.0
JPEG-2000 (ISO/IEC 15444-1:2004)
Information retrieval (Z39.50)—application service definition and protocol specification (ISO 23950:1998)
W3C XLink 1.1 Schema

Table 2 -- Foundational SDI Standards (Source: SDI Cookbook)

"Core" SDI Standards
OGC Web Map Service 1.3
OGC Web Feature Service 1.1
OGC Filter Encoding 1.1
OGC Web Coverage Service 1.1.2
OGC Geography Markup Language 3.2.1
OGC Catalogue Service 2.0.2 HTTP protocol binding (CS-W)
OGC Catalogue Service 2.0.2 HTTP protocol binding (CS-W) ebRIM and ISO Profiles

ISO 19115:2003 and ISO/TS 19139:2007
OGC KML 2.2
OGC WPS 1.0 + corrigenda
“Supplemental” SDI Standards
OGC Styled Layer Descriptor 1.1
OGC Web Map Context 1.1/Corrigendum 1
Future SDI Standards
OGC Web Coverage Service 2.0, corrigenda, and KVP, XML/POST, and XML/SOAP protocol binding extensions
OGC Web Feature Service 2.0/ISO 19142:2010
OGC GML 3.3
OGC Filter Encoding 2.0

Table 3 -- Other SDI Standards (Source: SDI Cookbook)