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1 Introduction – Standards Framework for GETIS

The set of standards frameworks available to support an interoperable geo-processing network in Europe has changed since the GETIS project was first proposed. Most significantly, a Web-based distributed geoprocessing architecture developed by the Open GIS Consortium, Inc. (OGC) has been maturing on top of the IT industry's underlying Web Services architecture. This Web-based architecture, a result of international consensus among major geoprocessing technology providers and users, provides a clear way forward.

GETIS will focus on solutions built with commercial products that implement interfaces based on OGC's OpenGIS implementation specifications. These specifications are platform-dependent, but because the platform is the World Wide Web, no single vendor controls the platform. The Web is the one distributed computing platform that all commercial software providers are building on today, and it is a platform that promises maximum opportunities for interoperability, integration of geospatial and non-spatial information, and dissemination of geospatial information and services.

The ISO standards referenced in earlier GETIS documents (see Annex 1) are still relevant, but they are abstract and platform-independent standards, not implementation specifications. OGC has a good working liaison with ISO TC/211 Geographic Information/Geomatics, so OGC and ISO TC/211 work programs are largely harmonized. OGC strives to keep its specifications within the abstract outlines of ISO's specifications, and ISO TC/211 (and to a lesser extent TC/204) strive to track OGC's development of implementation specifications in their development of abstract specifications. One benefit of this cooperation is that more minds are focussed on the issues. Another is that if the Web is replaced by another platform in the future, an abstract framework will be available to ease the transition.

This report provides a description of the standards that underlie the GETIS architecture and a description of the architecture itself. This architecture is the information and services framework, which the GETIS partners recommend as the foundation of a European Geo-Processing Network.



This report documents a rapidly changing process. After six months some details will have changed, so, as long as the project continues, the GETIS partners will provide periodic updates to this report.

2 Scope

This report identifies the standards authorities whose standards are base standards for the GETIS project and, by defining a general geo-processing interoperability architecture – "the GETIS Architecture" – this report explains how these standards should be used together. It lists existing and pending standards that are part of this architecture and describes their roles.

The Exploitation Plan, a separate GETIS report, details the GETIS Use Case Operational Architecture, a more specific system architecture that addresses existing user processes in the Use Cases.

To define an architecture, as conceived in this project, it is necessary to define the interfaces that enable

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communication between components operating at different levels in the architecture. We begin by assuming that many of the interfaces specified by OGC (interfaces which, in many cases, have already been implemented in commercial products) are suitable for the Use Case Operational Architecture. But we also assume that if our analysis of the use cases is thorough, we will probably discover requirements for new interfaces or modifications to existing interfaces.

These new requirements can be communicated to OGC to guide OGC's OpenGIS® interface specification development efforts. OGC develops specifications in rapid-prototyping engineering testbeds sponsored by organizations who need specific interoperability interfaces. Thus GETIS-derived requirements may provide direction for post-GETIS testbeds undertaken to create new interfaces. Such testbeds (and also pilot projects undertaken to test interfaces and architecture) may or may not be managed by OGC-Europe (OGCE), but close communication with OGC will be recommended so that Europe derives maximum benefit from OGC's ongoing progress, and so that OGC may review and perhaps approve specifications derived in the European testbeds.



The GETIS Architecture depends on the IT industry's general Web services architecture, which is stable enough at this time to support active application development by thousands of developers and integrators worldwide. It is, however, evolving in ways that will affect the GETIS Architecture. This report will describe relevant elements of the general Web services architecture. Updates to the report will include comments on the evolution of these elements.

The GETIS project as originally conceived included a "domain modelling" effort which would have resulted in a prescribed family of data schemas appropriate to the use case. Since OGC's Geography Markup Language (GML) provides a new, more practical approach to creating "families" of data schemas that can be used together, and because it provides other features that will benefit data schema coordination efforts, domain modelling is no longer a part of the GETIS project. The GML-based approach will be described with examples based on GETIS use cases, but development, modification, or translation of whole data schemas using the new approach is beyond the scope of GETIS.

As Web access to geodata and geoprocessing resources becomes common, it will be necessary to have automated methods of discovering these resources. Just as HTML metadata provides structured text that enables web browsers to help users find web pages containing specified text, metadata describing geodata and geoprocessing resources will be necessary to help users find and use these spatial resources. Metadata will be encoded in XML, and standard metadata schemas will be necessary to enable fully functional search capabilities. This requirement will be documented in the Exploitation Plan, but specification and use of metadata schemas is beyond the scope of GETIS.

3 Global Geo-Processing Standardisation Processes

It is essential, when embarking on a study of standards relevant to creating a European Geo-Processing Network, to focus on what is important. Many standards are no longer important. Some have focused on

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national needs and are not relevant in the pan-European context. Some have become irrelevant with the passing or evolution of underlying computer technologies and changes in the market. Some have become part of the infrastructure and are so far down in the technology stack (consider computer graphics standards, for example) that we can ignore them.

Until recently, many geospatial standards attempted to normalize the encoding of information in software systems (data format standards and data transfer standards). OGC has taken a different approach, creating open, common *interfaces* between software components. These interfaces provide access across networks to data and processing resources available on remote servers. This is the same object-oriented strategy taken by the Object Management Group (OMG) and more recently by the organizations that are building the international infrastructure for Web-based distributed geoprocessing. A key benefit of this "layered" approach is that legacy systems need not be replaced. Old, proprietary data formats need not be "transferred" into more generic formats and proprietary processing systems need not be changed. Legacy systems simply need to be "wrapped" with software that provides an open interface for communication with other clients and servers on the network. It doesn't matter which standards the underlying systems implement internally, as long as the network interfaces are standard, and also scoped to enable connection to the main capabilities of the underlying system.

Other geospatial standards have focused on the naming of feature types and feature relationships (data dictionaries, or "data schemas"). This is a semantic interoperability issue. A second semantic issue, schemas for descriptions of data sets (metadata schemas), is related to data schemas because metadata usually includes the data dictionary of the data it describes. Semantic interoperability is a separate problem from the "technical interoperability" issue described in the previous paragraph, but the advance of technology is also changing this problem space. As mentioned in the previous section, OGC's Geography Markup Language (GML) provides a new approach to creating "families" of data schemas that can be used together, and it provides other features that will benefit data schema coordination efforts. Data coordination is still important, but it will get much easier, and data sharing will be possible even when the two sharing Information Communities use somewhat different data schemas.

As mentioned above, ISO TC 211 Geographic Information/Geomatics is the main *de jure* standards organization of importance to GETIS. In Europe, the others that might be mentioned are CEN TC 287 Geographic Information ... [WHAT CAN WE SAY ABOUT CEN TC 287?]

Digital Geographic Information Working Group (DGIWG), which was established in 1983 to develop standards to support the exchange of Digital Geographic Information among NATO nations. (Membership has since expanded beyond NATO nations.) DGIWG developed and maintains DIGEST as an exchange standard. DGIWG activity includes dataset specification development and harmonization of standards, including harmonization of DIGEST with the NATO Secondary Imagery Format (NSIF) and with the International Hydrographic Organization S-57 data. DGIWG works closely with ISO TC 211 and other standardization and geospatial requirement organizations, coordinating common requirements and national initiatives relating to data access services, data quality, and metadata.

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Each European country has worked on national data coordination issues, but little has been accomplished in the area of Pan-European data schemas which would impact GETIS.

The standards organizations that are relevant to GETIS and to the development of a European Geo-Processing Network are described in the next section.

4 Standardisation Processes Relevant to GETIS

The standardization processes relevant to GETIS are the processes that are managed by OGC, ISO TC/211, and W3C and the major IT infrastructure companies who are developing the general Web Services infrastructure.



4.1 OGC

Beginning in 1994 OGC began creating open, common *interfaces* between software system components. These interfaces provide access across networks to data and processing resources available on remote servers. Somewhat ironically (since its goal, in effect, has been to make data formats irrelevant) OGC also has developed a data format standard, Geography Markup Language (GML), which is a standard way of encoding geodata and geoprocessing requests in the Web's Extensible Markup Language (XML). In addition to other benefits deriving from its XML character, GML offers new ways of resolving data schema inconsistencies.

OGC is not a *de jure* standards organization like ISO. It is an international industry consortium whose consensus process involves technology users and providers and whose objective is market enablement through interoperability between commercial geoprocessing software products. OGC adds implementation detail to the standards of *de jure* standards organizations, and extends *de jure* standards whenever the marketplace needs stricter guidelines to experience greater growth.

4.2 ISO

ISO is an international *de jure* standards organization that provides nations with an opportunity to participate in a democratic process to develop standards that benefit industry and commerce. OGC and ISO TC211 have an agreement to sustain the technical alignment of their respective developments. This is accomplished through mutual review and development of draft documents. When lack of agreement is discovered, steps are taken to evolve a common and consensus view. In many ways, OGC can be viewed as implementing (or adding an implementation layer on top of) ISO TC211 standards. When an OGC specification meets certain requirements, ISO will adopt it as an ISO specification. The agreement provides for sharing of private documents, freedom from certain copyright restrictions, and access to each other's experts.

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4.3 Web Services Infrastructure: W3C and Major IT Companies

W3C and major IT companies are developing the general Web Services infrastructure that supports Web-based distributed geoprocessing. Web Services make the Web and the Internet a platform for delivery of *services*, not just data. Services are self-contained, self-describing, modular applications that are published, discovered, and invoked across the Web. (Examples of fundamental *geospatial services* that could be served over the Web are “polygon overlay”, “point to grid interpolation” and “coordinate transformation”.)

Even though major IT companies like IBM, Microsoft, Sun, Oracle, and Hewlett-Packard promote competing architectures, certain key standards are in place and the IT industry is moving toward consensus on other key standards. Critical standards include:

XML (eXtensible Markup Language)

SOAP (Simple Object Access Protocol)

UDDI (Universal Description, Discovery, and Integration)

WSDL (Web Services Definition Language), which deals with service interface definitions (types, messages, port types) and protocol bindings, service type taxonomy, descriptive information about behavior and semantics of a service type.

These companies' application server and middleware offerings can be proprietary, offering unique value of various kinds, and still work within the emerging overall interoperability framework.

Below the level of the Web is the Internet. GETIS depends on the Internet but is not concerned with its technical details or with the organizations that maintain its standards.

5 Standards Relevant to GETIS

5.1 Existing and Pending OpenGIS Specifications



(The following was adapted from the document "Overview of OpenGIS Implementation Specifications (January 2002)" available on OGC's Web Site, <http://www.opengis.org>.)

5.1.1 Introduction to OGC Specifications

The OGC Technical Committee has developed a comprehensive reference model called the *OpenGIS Abstract Specification*. The Abstract Specification provides a framework, or abstract model, for the OGC Technical Committee and participants in OGC's test beds who are developing *OpenGIS Implementation Specifications*. Implementation Specifications provide software engineers and developers information about a given specification as well as specific programming rules and advice for implementing the interfaces and/or protocols that enable interoperability between spatial processing systems.

There are three levels of OpenGIS Implementation Specifications:

Approved (or “**Adopted**”) **Implementation Specifications** are completed specifications that have received

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consensus approval according to the guidelines detailed in the TC Policy and Procedures and have also been approved by the OGC Planning Committee. These specifications are published on OGC's public web site.

Candidate Implementation Specifications are specifications that are moving through OGC's approval process but have not yet been formally adopted. A Candidate Implementation Specification is a Discussion Paper for public review, a Request for Comment (RFC), a Recommendation Paper, or a Draft Specification that an OGC Technical Committee Special Interest Group (SIG) has begun to review. Candidate Specifications are typically defined, developed, and tested in the OGC Interoperability Program. The results of this work are published as Draft IP Report or IP Reports.

Planned Implementation Specifications are specifications that are being discussed but that have not yet been formally addressed in the specification development process. These are not described in this paper. For information about planned specifications in a particular technology area, contact the chair of the relevant OGC Technical Committee SIG.

The Technical Committee also reviews and approves **OpenGIS Recommendation Papers** for release for public discussion. A Recommendation Paper presents an official OGC position on a given topic, such as a draft Implementation Specification. It is not, however, an Approved Specification. OGC Recommendation Papers are published for public review and comment and they may result in either Approved Abstract Specifications or Approved Implementation Specifications.



OpenGIS Implementation Specifications can be grouped by category or domain of service:

Core Services: These are interfaces that are typically required regardless of application area or business domain. These are services that support the other application areas or domains of service described below. Core service examples are: the OpenGIS Coordinate Transformation Specification, the OpenGIS Catalog Specification, and the Draft OpenGIS Services Registry Specification.

OpenGIS Web Mapping Services: This is a family of specifications that enable servers to dynamically query, access, process, and combine different types of spatial information over the web with OpenGIS Specification conformant servers developed by other companies and organizations. To date, OGC has developed three Web Mapping Service specifications: OpenGIS Web Map Server Specification (Approved), OpenGIS Web Feature Server Specification (Adopted)), and a OpenGIS Web Coverage Server Specification (Candidate). Ongoing work includes specification of a services registry and the interfaces to that registry, an XML encoding for a sensor protocol language (SensorML), and an interface specification for interacting with sensor webs.

OGC Location Services (OpenLS): Location Services will depend on consistent communication of location (and time), route, types of service, etc. across technology platforms, application domains, classes of products, and national regions. OpenGIS Implementation Specifications in this domain will address:

- Integration with mobile terminals, wireless platforms, IP platforms, GPS, etc.
- Extended and spatially enabled yellow page search and display
- Dynamic route determination and display
- Geocode and gazetteer services
- Interactive map/feature display

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Location services depend on *Gateway Services*, services that integrate these location application services with common mobile terminals, wireless platforms, Internet Protocol (IP) platforms, and/or mobile position determination systems. Gateway Services operate between wireless-IP systems and location application servers. Candidate Gateway Services include:

- *getDeviceLocation* service—Acquires the current position of a terminal from the mobile positioning server that is in use by a wireless operator.
- *ContentTranscoder* service—Handles the transcoding of content, depending on terminal characteristics.
- *Portal* service—The Web Gateway Server between location application servers and mobile terminals. Handles customization, privacy and security.

OpenGIS Geospatial Fusion Services: Non-map information – text, video, audio, digital photographs, , sensor data, word processing documents, etc. – often refers to place. It would be useful in many situations to be able to "fuse" information such as addresses, place names, coordinates, pinpoints on photographs, and descriptive directions into one information management framework that would support search, discovery, and sharing of spatial information stored in non-map formats. This is the goal of OGC's "Geospatial Fusion Services (GFS)," which currently include: OpenGIS Gazetteer Service Interface (Discussion Paper) , OpenGIS Geocoder Service Geocoder (Discussion Paper), OpenGIS GeoParser Service Discussion Paper), and OpenGIS Location Organizer Folder (LOF) Specification.



5.1.2 Approved Specifications

5.1.2.1 OpenGIS Catalog Service Interface Specification (Approved)

The OpenGIS Catalog Service Interface Specification defines a common interface that enables diverse but conformant applications to perform discovery, browse and query operations against distributed and potentially heterogeneous catalog servers. Spatial Catalog servers typically contain metadata about spatially referenced information such as maps, schematics, diagrams, or textual documents. The specification uses metadata and spatial location to identify and select layers of interest, and provides for interoperability in catalog update, maintenance, and other Librarian functions. The specification is designed for catalogs of imagery, geospatial information, and mixtures of the two. (Future versions of the specification may also support services.) It specifies open APIs that provide discovery services, access services and interfaces for catalog managers, including a complete Catalog Query Language. Detailed implementation guidance is provided for establishing and ending a stateful catalog session to: query the catalog server properties, check the status of a request, cancel a request, issue a query, present the query results, and get the schema of a discovered collection.

5.1.2.2 OpenGIS Coordinate Transformation Services Specification (Approved)

This Implementation Specification provides interfaces for general positioning, coordinate systems, and coordinate transformations. In the specification, coordinates can have any number of dimensions, so this

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specification can handle both 2D and 3D coordinates as well as higher orders.

Earth coordinates, such as the coordinates provided by a GPS receiver or by traditional surveying or navigation methods, are meaningful only as offsets from the origin in a particular spatial reference system. Many people outside the geospatial professions assume that longitude and latitude are universal and sufficient, but in fact there are a number of distinctly different longitude-latitude spatial reference systems in common use. A key requirement for overlaying views of geodata ("maps") from diverse sources is the ability to perform *coordinate transformation* in such a way that all spatial data use the same *spatial reference system*. Since there cannot be an assumption that all spatial data sources will be in the same projection or coordinate system, it is necessary for the client or application to be able to specify what coordinate system the data servers should deliver the spatial data to the application in. Therefore, put simply, OGC's OpenGIS Coordinate Transformation Services Specification provides a standard way for software to specify and access coordinate transformation services for use on specified sets of spatial data.

5.1.2.3 OpenGIS Geography Markup Language (GML 2.1) (Approved)

The Geography Markup Language (GML) is an XML encoding for the transport and storage of geographic information, including both the geometry and properties of geographic features. As with the OpenGIS Simple Feature Specification, GML utilizes the OpenGIS Abstract Specification geometry model. However, unlike the Simple Features Specification, the GML Specification includes the ability to handle complex properties.

OGC members forecast that GML will make a significant impact on the ability of organizations to share geographic information with one another and to enable linked geographic data sets, because GML was designed to:

Provide a means of encoding spatial information for both data transport and data storage, especially in a wide-area Internet context;

Be sufficiently extensible to support a wide variety of spatial tasks, from portrayal to analysis;

Establish the foundation for Internet GIS in an incremental and modular fashion;

Allow for the efficient encoding of geo-spatial geometry (e.g. data compression);

Provide easy-to-understand encodings of spatial information and spatial relationships, including those defined by the OGC Simple Features model;



Be able to separate spatial and non-spatial content from data presentation (graphic or otherwise);

Permit the easy integration of spatial and non-spatial data, especially for cases in which the non-spatial data is XML-encoded;

Enable easy linking of spatial (geometric) elements to other spatial or non-spatial elements;

Provide a set of common geographic modeling objects to enable interoperability of independently-developed applications.

GML is positioned as an open data exchange standard, well suited for transmitting small to medium-sized volumes of information. GML is usable with all standard XML tools. Of particular note in this respect are the tools designed to filter XML (XSL) and to turn XML into a visual presentation (XSLT). Using the XSL tools, a

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fully functional GML database can be published into more limited versions. For example, in order to satisfy regulatory requirements, a subset of the data, perhaps with lower fidelity, can be automatically extracted. To share data with a supplier who is also a potential competitor, the data can first be filtered and adjusted on the basis of what the supplier needs to know.

GML 3.0 is a planned implementation specification.

5.1.2.4 OpenGIS Grid Coverages (Grid, Image, DEM) Specification (Approved)

This specification was designed to promote interoperability between software implementations that provide grid analysis and processing capabilities. Within the OGC context, a Coverage is a function or any set of entities that exhaustively cover a plane. A grid coverage is a specific case of coverage in which a set of grid values covers the surface. Examples of a grid coverage are satellite images, digital elevation models, and digital orthophotos.

The OpenGIS Grid Coverages Implementation Specification APIs provide for basic image access for purposes of requesting and viewing a grid coverage and performing certain kinds of analysis such as histogram calculation, image covariance and other statistical measurements. The specification provides a number of interface features for dealing with color palettes, byte organization, metadata, and coordinate systems (as set forth in the OpenGIS Coordinate Transformation Specification).



5.1.2.5 OpenGIS Simple Features Specification (Approved)

The Simple Feature Specification (version 1.x) focuses on the interface for OpenGIS Simple Features. A Simple Feature is defined by the OpenGIS Abstract specification to have both spatial and non-spatial attributes. Spatial attributes are geometry valued, and simple features are based on 2D geometry with linear interpolation between vertices. The base Geometry class has subclasses for Point, Curve, Surface and Geometry Collection. Each geometric object is associated with a Spatial Reference System, which describes the coordinate space in which the geometric object is defined. The supported geometry types include points, lines, linestrings, curves, and polygons. Feature-to-feature relations are not supported.

The OpenGIS Simple Feature Specification application programming interfaces (APIs) provide for publishing, storage, access, and simple operations on Simple Features. The APIs take into account such tasks as the establishment of linear and angular units, spheroids, datums, prime meridians, and map projections. Included are interfaces for common geometric and topological constructs such as convex hull, symmetric difference, closure, intersection, buffer, length, distance, and dozens of others. At the GIS feature level, the API's provide for the creation and management of feature collections (such as the set of all roads in Howard County, or regions where ground cover is hardwood forest), and the ability to access features from such collections using geometric, topological, or attribute modifiers.

5.1.2.6 OpenGIS Web Feature Server Specification (WFS) (Approved)

The Web Feature Server Interface Specification (WFS) describes data manipulation operations on OpenGIS

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Simple Features (e.g., points, lines, and polygons) so that servers and clients can communicate at the feature level. A WFS request – like those supported in many GIS and RDBMS packages – consists of a description of the query and data transformation operations that are to be applied to WFS enabled spatial data warehouses on the Web. The request is generated on the client and is posted to a WFS server. The WFS Server reads and executes the request, returning the result in a feature set as GML. A GML enabled client then can use the feature set.

In contrast to the OGC Web Map Server implementation, which delivers a picture, a WFS implementation in a client supports the dynamic exploitation and access of feature (vector) data and associated attributes. This capability opens the door to enhanced spatial analysis, modeling and other operations based on the attributed data. The WFS Specification also describes interfaces to support transactions to create a feature, delete a feature, and update a feature.

Bundled with the WFS specification is the Filter Encoding Specification, which defines a standard encoding for query predicates using XML. Using XML encoding, a query operation can be defined that retrieves objects that lie in a particular region. Similarly, a delete operation could be restricted to those object instances that lie in a particular region and have a particular value for some specified non-spatial property.

5.1.2.7 OpenGIS Web Map Server Interface (WMS 1.1.1) Specification (Approved)

The OpenGIS Web Map Server Specification (WMS) is a set of interface specifications that provide uniform access by Web clients to maps rendered by map servers on the Internet. Thus, WMS is a service interface specification that :

Enables the dynamic construction of a map as a picture, as a series of graphical elements, or as a packaged set of geographic feature data;



Answers basic queries about the content of the map;

Can inform other programs about the maps it can produce and which of those can be queried further.

The Web Map Server Interface provides four protocols (*GetCapabilities*, *GetMap*, *GetFeatureInfo* and *DescribeLayer*) to support the creation and display of registered and superimposed map-like views of information that come simultaneously from multiple sources that are both remote and heterogeneous.

GetCapabilities allows a client (or client proxy) to request a server to expose its mapping content and processing capabilities. *GetMap* enables a client to request multiple servers to craft “map overlays”, possessing the identical spatial reference system, size, scale, and pixel geometry. These overlays can be ordered and placed by the client into a display, and optionally, using transparent pixel technology, the information from several sources can be rendered for immediate human viewing. *GetFeatureInfo* enables a user to click on a pixel and inquire about the schema and metadata values of the feature(s) represented there. *DescribeLayer* provides information about the layer. OGC is finalizing standards for Legends and Style Layer Descriptors that will further enhance the ability of WMS to provide consistent depiction of spatial information acquired via distributed servers on the Internet.

Both the Web Map Server (WMS) and the Web Coverage Server (see below) provide for the generation and

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delivery of raster-based information. The WMS returns an “image,” that is, an array of pixel values ready for portrayal. Unlike the WMS, where only visualization and limited query are supported, the coverage server provides for analysis involving the evaluation/manipulation/combination of many coverages to answer specific questions. The Web Feature Service, by contrast, returns a collection of vectors that inform the client of values of interest, such as temperature, ownership, average rainfall, and so on.

5.1.3 Candidate OpenGIS Implementation Specifications

5.1.3.1 OpenGIS Gazetteer Service Interface Specification (GAZ) (Discussion Paper)

A **Gazetteer Service** is a network-accessible service that retrieves the known geometries for one or more features, given their associated well-known feature identifiers (text strings), which are specified at run-time through a query (filter) request. The identifiers are any words or terms that describe the features, which are well known to the Gazetteer Service, such as a set of place names and/or landmarks. Each instance of a Gazetteer Service has an associated vocabulary of identifiers. Thus, a Gazetteer Service may apply to a given region, such as a country, or some other specialized grouping of features. The returned geometries are expressed in an OGC Spatial Reference System according to the ISO feature model, encoded in GML.



A **Gazetteer Service** may be thought of as a special case of a Geocoder Service that is an authority for place names and their associated geometries. This is expected to be consistent with the definition of a gazetteer in ISO CD 19112 – “Geographic Information – Spatial referencing by geographic identifiers”. This specification adopts a data model based on CD 19112, with derivation and mappings explicitly noted. This has been extended with optional elements whose contents have application defined semantics to support the Alexandria Digital Library Gazetteer Content Model, without losing explicit semantics derived from the ISO model.

5.1.3.2 OpenGIS Geocoder Service Specification (Discussion Paper)

Geocoding is the process of linking words, terms and codes found in a text string to their applicable geospatial features, with known locations. (Locations are defined as geometry; usually points with x, y coordinates.) The most commonly known type of geocoding is converting an address to a geographic location. The current Geocoder Interface Specification allows for a request providing an address or set of addresses and returns them along with the corresponding geometry (usually a point relative to a requested spatial reference system.) The request is “sent” to a geocoding service that processes the request and returns the result.

5.1.3.3 OpenGIS GeoParser Service Specification (Discussion Paper)

Geoparsing refers to the capability to process a textual document and identify key words and phrases that have a spatial context. A GeoParsing Interface implementing this specification works in the context of two bodies of information: a reserved vocabulary (usually of place names) and a text source (e.g., a newspaper or voice track.) The GeoParser returns all occurrences of the use (in the text source) of any word in the reserved

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vocabulary. Each occasion establishes a geolink between the source and the location associated with the reserved word. For example, your home might be Geolinked with your water bill through their common address.

5.1.3.4 OpenGIS Location Organizer Folder Specification - LOF (Discussion Paper)

The Location Organizer Folder (LOF) is a GML document that provides a structure for organizing the information related to a particular event or events of interest. It may be used in various analysis applications, like disaster analysis, Intelligence analysis, etc. It is spatially enabled, and capable of managing disparate types of information.

The LOF is an information structure. There may be a variety of services external to the LOF that provide the means for generation and manipulation of the information in the structure. This includes search and discovery, parsing different resources and extracting useful information, assigning spatial attributes, relating (linking) resources of interest, and so on.

This LOF concept and specification was created as a part of the OGC Geospatial Fusion Services Testbed (GFST 2000) and Geospatial Fusion Services Pilot Project (GFSP 2001). Even though the LOF is meant to be a generic structure, it is not completely independent from the services that process it, which were also built during these GFS projects. Thus, the LOF specification as it is currently documented describes the structure of the LOF, and to some extent, the system and some of the services that process the LOF. In the future, it is envisioned the LOF will become a completely generic information structure, de-coupled from any specific component that can use it.

5.1.3.5 OpenGIS Image Coordinate Transformation Specification (ICT) (Candidate)

Interfaces that implement this specification will provide the capability for a client to invoke a service that generates measurements of ground objects by making measurements of their images. Such interfaces will also allow services that perform image rectification and orthorectification.



5.1.3.6 OpenGIS Stateless Catalog Specification (Cat S) (Candidate)

A stateless catalog allows clients to invoke arbitrary catalog services without reference to previous invocations. It avoids the need for lengthy sessions, which are difficult to manage in wireless, mobile, and distributed environments.

5.1.3.7 OpenGIS Styled Layer Descriptor Specification (SLD) (Draft IP Report)

A basic tenet of OpenGIS® Specifications is the separation of information from presentation. However, presentations are nevertheless of critical importance, so interfaces must be developed that enable a client to express that a particular “view” be created of a feature collection. The SLD is an encoding specification for associating presentation rules with properties of features.

The SLD Discussion Paper explains how the Web Map Server (WMS 1.0 & 1.1) specification can be extended

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to allow user-defined symbolization of feature data. It should be read in conjunction with the latest version WMS specification. At the time of writing the latest version WMS specification is specified in the WMS 1.1.1 Specification.

5.1.3.8 OpenGIS Web Coverage Server (WCS) Specification (Candidate)

The OpenGIS Web Coverage Server extends the Web Map Server (WMS) interface to allow access to geospatial "coverages" that represent values or properties of geographic locations, rather than WMS generated maps (pictures). That is, both the WMS and the WCS provide for the generation and delivery of raster-based information, but the WMS returns an "image" which is an array of pixel values ready for portrayal. The WCS returns a collection of vectors that inform the client of values of interest, such as temperature, ownership, average rainfall, and so on. In contrast to the WMS, where only visualization is accomplished, the coverage server provides for analysis involving the evaluation/manipulation/combination of multiple coverages to answer specific questions. These values must be further processed if they are to be portrayed. This access to intact, unprocessed geospatial information is needed for client side processing, multi-valued coverages, and input into scientific models and other clients beyond simple viewers. The Web Coverage Server specifies two operations: GetCapabilities and GetCoverage.



5.1.3.9 OpenGIS Web Registry Service Specification (Candidate)

The OpenGIS Web Registry Service Specification provides for a registry of parameters, e.g. parameters for converting a Mercator projection to a Lambert projection, for specific datums, etc. This meets the need for a service on the web to manage the business of accepting a request for these parameters and issuing them along with information about the confidence we can have in these parameters.

NATO, for example, could stand up a registry for DIGEST, which is a list of all object types of interest to NATO, in 7 languages, and all the attributes that are required, optional, and forbidden for a feature. With such a registry, it will be necessary to have a server that makes it possible to add a feature. A registry service will tell what attributes are required, optional, etc. It will also be necessary to have a registry of data sources, and registries of symbols. Each registry will need a registrar with tools that accept/reject/note. Other authorities tell the registrar what to do, and that implies interfaces for these authorisations. The registry server hosts information of various types and makes the information available across the web in authoritative fashion, with appropriate authorisations and appropriate metadata. Registries are recursive.

5.1.3.10 OpenGIS XML Imagery Mark Up Language Specification (XIMA) (Draft IP Report)

This document defines an XML vocabulary to encode annotations on imagery, maps, and other geospatial data. This vocabulary draws on the Geography Markup Language (OpenGIS® GML Recommendation Paper, Revision 2.0, OGC Document #01-016) to express the positions of these annotations in geographic (real world) or image-pixel coordinates, and to associate each annotation with the geospatial resource(s) it describes. Encoding annotations using such a vocabulary will let Web-GIS users more easily and flexibly:

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- Interchange annotated maps and images,
Integrate image interpretations with raw imagery, and
Converse geographically over images and maps.

These activities are of particular interest to the defence and intelligence community, which first articulated the need for such an encoding scheme. However, the XML encoding presented here is also useful for any activity that requires linking or tagging geospatial data in order to discuss it with others, to make joint decisions, or to communicate spatially.

The XIMA Discussion Paper presents, first, several encoding requirements for annotations, illustrating each one with simple examples. It then proposes a simple XML Schema that meets those requirements. Finally, it explains how one might apply or adapt the Location Organizer Folder (LOF), devised within the OpenGIS Geospatial Fusion Services Testbed, to the case of image and map annotations.

5.1.3.11 Web Terrain Server (Discussion Paper)

A Web Terrain Service (WTS) produces views of georeferenced data – typically 3-dimensional coverages. We define a "view" as a visual representation of some geodata; a view is not the data itself. These views are generally rendered in a pictorial format such as Portable Network Graphics (PNG), Graphics Interchange Format (GIF) or Joint Photographic Expert Group (JPEG) format. This specification standardises the way in which clients request views and the way that servers describe their data holdings. Three required operations are defined:

GetCapabilities: Obtain service-level metadata, which is a machine-readable (and human-readable) description of the WTS's information content and acceptable request parameters.

GetView: Obtain a 3D scene whose geospatial and dimensional parameters are indirectly defined.



GetMap: Obtain a map whose geospatial and dimensional parameters are directly defined.

Initially, it was felt that the WMS interface could be extended to support rendering of 3d coverage data. Extending the WMS interface for the GetView operation requires a minor extension of the WMS GetCapabilities response. However, fulfilling the full range of potential three-dimensional scenes requires significant extension of the WMS request parameters. Moreover, one could imagine that a Terrain View Service might eventually include other terrain-specific operations such as GetFootprint and GetViewshed. There might also be an analogous operation to GetFeatures for three-dimensional geometry and three-dimensional annotation of terrain views. These add so many additional complexities that are out of the scope of a Web Map Service that a new Web Terrain Service has been proposed.

5.1.4 Recommendation Papers

5.1.4.1 OpenGIS Recommended Definition Data for Coordinate Reference Systems and Coordinate Transformations, Version 1.0.1

The Recommendation Paper on Definition Data for Coordinate Reference Systems and Coordinate

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Transformations (see <http://www.opengis.org/techno/specs.htm>) is a proposal for OGC standard definition data for Coordinate Reference Systems and Coordinate Transformations. This proposal is for review by the public, whose suggestions will be considered by the Coordinate Transformation Working Group. A variety of Implementation Specifications are expected to be based on the Data Model specified in this paper.

Coordinates of a position or location are unambiguous only when the coordinate reference system on which those coordinates are based is fully defined. Each position is described by a set of coordinates based on a specified coordinate reference system. This paper specifies data for defining coordinate reference systems for point coordinates.

Coordinates from different datasets often have different coordinate reference systems. In order to use together positions from different coordinate reference systems, known point coordinates often must be transformed into the corresponding coordinates in a different coordinate reference system. This paper specifies data for defining such coordinate transformations.

5.1.5 Gap Analysis

The rapid pace of OGC's OpenGIS Specification development ensures that some of the pending specifications listed above are now or soon will be approved specifications, and new specifications will have been introduced in the "pending" list. Analysis of the GETIS use cases will reveal if there are requirements for services which have not, at the time of analysis, been addressed in OpenGIS Specifications.



5.2 Existing and Pending Web Services Infrastructure Standards

Within the framework of established and in-process Web standards maintained by the Worldwide Web Consortium (W3C), a number of large, well-known companies are developing and promulgating web services visions of their own. Some of this is a matter of market positioning. Under all the marketing messages lie some very strong efforts at developing a web services infrastructure. Most prominent among these are SOAP (Simple Object Adaptor Protocol), UDDI (Universal Description and Discovery Interface), and WSDL (Web Services Description Language). These efforts, while somewhat overlapping, form a layering of interface and service description and query mechanisms that address the needs of Web-based distributed geoprocessing.

5.2.1 SOAP

[SOAP](#) is a protocol specification that defines a uniform way of passing XML-encoded data. It also defines a way to perform remote procedure calls (RPCs) using HTTP as the underlying communication protocol.

SOAP arose from the realization that no matter what the current middleware offerings are, they need a Wide Area Network wrapper. Architecturally, sending messages as plain XML has advantages in terms of ensuring interoperability. The middleware players seem willing to put up with the costs of parsing and serializing XML in order to scale their approach to wider [networks](#).

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Submitted in 2000 to the W3C as a Note by IBM, Microsoft, UserLand, and DevelopMentor, the further development of SOAP is now in the care of the W3C's [XML Protocols](#) Working Group. This effectively means that SOAP is frozen and stable until such time as the W3C Working Group delivers a specification.

5.2.2 UDDI (Universal Description, Discovery and Integration Service)

[UDDI](#) provides a mechanism for clients to dynamically find other web services. Using a UDDI interface, businesses can dynamically connect to services provided by external business partners. A UDDI registry is similar to a CORBA trader, or it can be thought of as a DNS service for business applications. A UDDI registry has two kinds of clients: businesses that want to publish a service (and its usage interfaces), and clients who want to obtain services of a certain kind and bind programmatically to them.

5.2.3 WSDL (Web Services Definition Language)

[WSDL](#) provides a way for service providers to describe the basic format of web service requests over different protocols or encodings. WSDL is used to describe *what* a web service can do, *where* it resides, and *how* to invoke it. While the claim of SOAP/HTTP independence is made in various specifications, WSDL makes the most sense if it assumes SOAP/HTTP/MIME as the remote object invocation mechanism. UDDI registries describe numerous aspects of web services, including the binding details of the service. WSDL fits into the subset of a UDDI service description.

WSDL defines services as collections of network endpoints or *ports*. In WSDL the abstract definition of endpoints and messages is separated from their concrete network deployment or data format bindings. This allows the reuse of abstract definitions of messages, which are abstract descriptions of the data being exchanged, and port types, which are abstract collections of operations. The concrete protocol and data format specifications for a particular port type constitute a reusable binding. A port is defined by associating a network address with a reusable binding; a collection of ports define a service

5.2.4 Scalable Vector Graphics (SVG) for styling of GML data.

SVG is not a Web services standard, but a standard application programming interface (API) for displaying graphics encoded in XML. It is necessary for presentation of GML data.

5.2.5 Gap Analysis

Analysis of the GETIS use cases will reveal if these service infrastructure elements provide adequate support.

5.3 Existing and Pending ISO Standards

As mentioned in section 1, ISO TC/211's platform-independent abstract standards provide a connection

between legacy, current, and future technology. This connection is reliable to the degree that OGC and ISO TC/211 maintain their effective liaison.

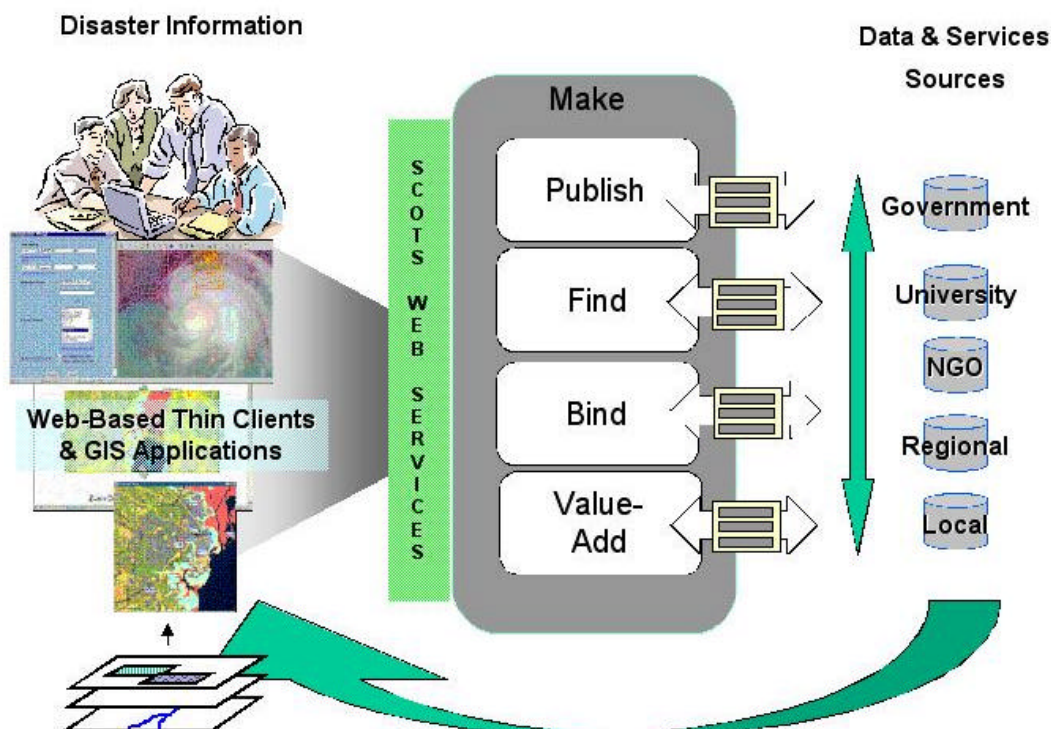
Because the relevant ISO TC/211 standards are not implementation specifications and are not referenced directly in the GETIS architecture which is described in the next section, we have listed them in an annex.

6 GETIS Architecture



“Architecture” is defined by:

1. *System concept* illustrating setting, components, and interfaces.
2. *Use cases* describing system from users' point of view.

The diagram below depicts the GETIS architecture. Details await more fully developed use case scenarios and an exploitation scenario.



Via the Web services in the middle, users on the left access data and services provided by Web-resident servers on the right. Just as non-spatial Web pages "publish" their contents – make them discoverable – through HTML metadata, geodata and geoprocessing services servers will publish their contents through XML metadata contained in feature type registries, feature instance catalogs, and service registries. Clients, which might be applications or thin clients on users' computers or which might be other services, find data and services based on what is published in such registries and catalogs. Bind refers to service components

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connecting and executing. This depends, of course, on open interfaces. Value-Add refers to users being able to make changes in datasets which add value in terms of adding feature data and making corrections to data.

7 Conclusions

A review of available standards frameworks to support a European Geo-Processing Interoperability Framework leads to the conclusion that there is a practical framework available, the Web-based OGC Web Services (OWS) framework. OWS enables automatic publishing and discovery of geodata and geoprocessing services, and automated chaining and execution of these services.

Enough framework elements are already implemented in commercial products to enable demonstrations and limited practical applications. OWS is under active development, which means that new services are added every few months, and the international OGC process is open to input from European users. A GETIS use case will lead to a particularized instance of the OWS framework.

Part of the framework, GML, is a standard for encoding geodata and geoprocessing instructions in XML. GML opens the door to greater flexibility in data sharing among Information Communities whose data schemas are similar but not the same, and enables the development of new Web-based tools to facilitate data coordination.

8 Annex 1 – ISO TC/211 Standards

A number of ISO TC/211 standards are relevant to GETIS because they provide an abstract, platform-independent model which complements OGC's Web platform implementation specifications. The most significant of these are described below.

ISO/TR 19121:2000 Geographic information - Imagery and gridded data reviews the manner in which raster and gridded data is currently being handled in the Geomatics community in order to propose how this type of data should be supported by the geographic information standards. As such it should be the definitive work on the subject; however, it is already superseded by subsequent events primarily in the Open GIS Consortium Work Programme. This document notes that there are other efforts at standardising aspects of imagery and gridded data in different related fields or application areas:

The DIGEST Functional Standard addresses raster and matrix data.

The IHO is currently beginning work on handling synthetic scanned charts as raster data.



The work ongoing in ISO/IEC JTC 1/SC 24 on Computer Graphics and Image Processing.

Work done by DGIWG to harmonise the DIGEST standard with the work of ISO/IEC JTC 1/SC 24.

Compatibility with the NATO Secondary Imagery Format (NSIF).

Efforts are also underway in JTC 1/SC 32/WG 4 SQL/MM to create supporting data types and operators to manage, query, and disseminate image data.

The Open GIS Consortium has recently released an RFP study document on "Coverages" that is of

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importance for imagery and gridded data.

The report also describes de facto standards activities such as the Catalogue Interoperability Protocol (CIP), which is an early and specific catalogue approach to recording image availability for access by users.

It will be seen that ISO/TC 211 has concentrated on those aspects of standards that are needed to exchange a copy of data including schema, metadata, quality. ISO/TC 211 has tackled the issue of standard 'architecture patterns' for geospatial service developmentⁱ, proposing a platform independent solution in an OSE context.

Subsequent to the advanced development of ISO/TR 19121: 2000, ISO/TC 211 embarked on four other specifically focused work items:

ISO/CD 19123 Geographic information - Schema for coverage geometry and functions

ISO/PT 19124 Draft review summary from stage 0 of project 19124, Geographic information - Imagery and gridded data components

ISO TS 19129 Geographic information - Imagery, Gridded and Coverage Data Framework: this currently at working draft stage

ISO TS 19130 Geographic information - Sensor and data models for imagery and gridded data

The scope of 19123 is to 'define a conceptual schema for the spatial characteristics of coverages. Coverages support mapping from a spatiotemporal domain to attribute values where attribute types are common to all geographic positions within the spatiotemporal domain. A spatiotemporal domain consists of a collection of direct positions in a coordinate space. Examples of coverages include rasters, triangulated irregular networks, point coverages, and polygon coverages. Coverages are the prevailing data structures in a number of application areas, such as remote sensing, meteorology, and bathymetric, elevation, soil, and vegetation mapping'. The document is normatively referenced by the OGC Web Coverage Service (version 0.5).

The scope of 19124 is a schedule of 'impacts' on ISO/TC 211 standards as a result of the addition of specific imagery and gridded data objectives some 5 years after standards development work had started. 19124 reports that the only impact on 19123 might be the handling of multi-dimensional coverages and functions. ISO 19107 Geographic information - Spatial schema is an important normative reference for ISO 19123: 19124 reports the probable need for a spatio-temporal schema to '*include time as a dimension in hyperspatial image and gridded coverage data in accordance with the Reimannian Hypercube Structure*'. Otherwise this report remains a reasonable guide to the gaps in ISO/TC 211 at the schema level.

ISO 19129 'defines the framework for imagery, gridded and coverage data and those elements for imagery gridded and coverage data that require standardization that are not identified in other ISO 19100 standards'.

Their proposed framework is content oriented - see figure 4 below:

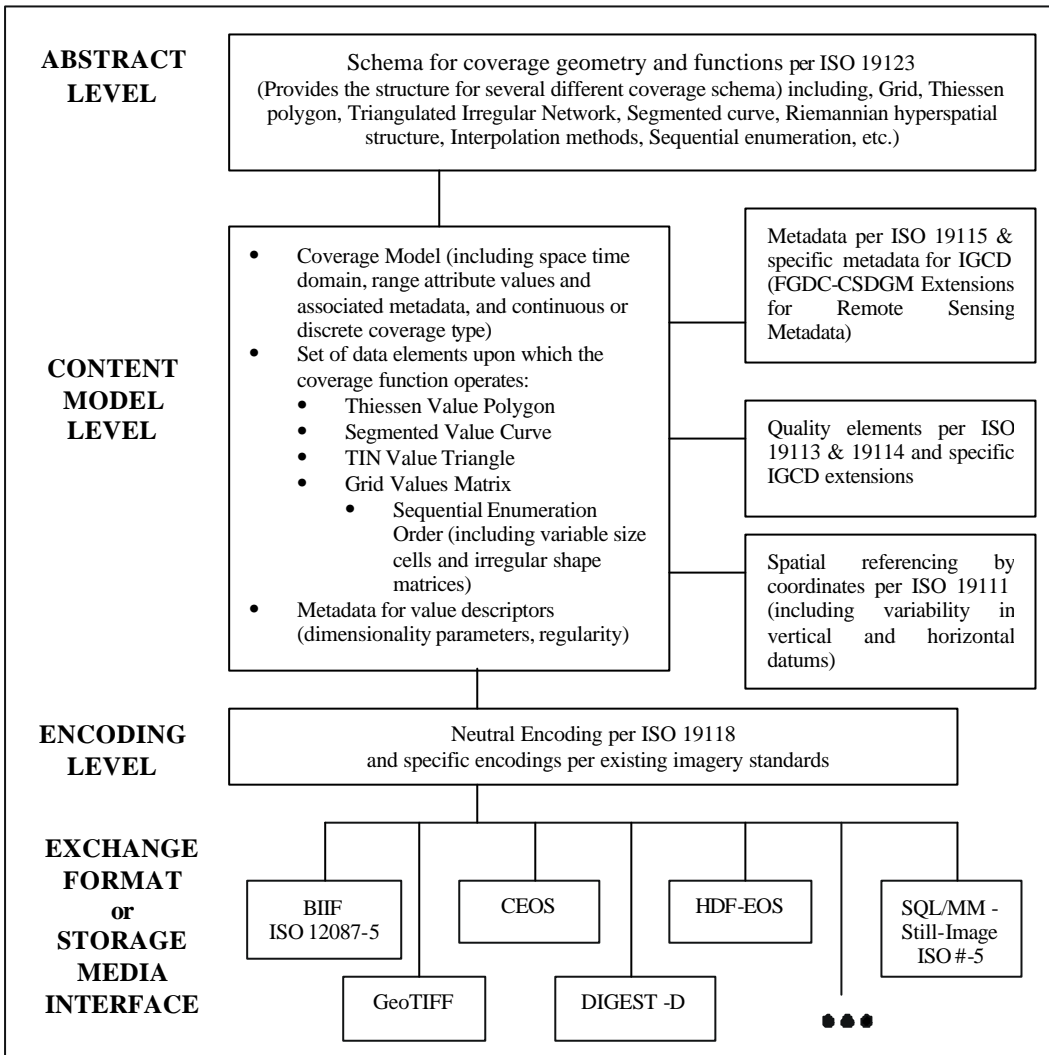




Figure 4 ISO 19124: Overall relationship between the elements of the framework

The definition of data schema, metadata schema and content will be significant for any Web coverage service and also for GETIS. However, it is the services aspect that is of major concern and this is not covered by this work.

ISO 19130 specifies the content of sensor models describing the physical and geometrical properties of each kind of remote sensing instrument that produces imagery. It provides the information necessary to derive the geographic or map location of points in the instrument coordinate system, when information on the configuration of the instrument is used to derive location. It provides the information required to determine the orientation and position of an instrument used in remote sensing'.

It 'also specifies the characteristics of a conceptual data model for each kind of sensor.'

It 'is applicable to data products intended for distribution, to specify what information needs to be provided along with the data. It does not specify the way in which the information is to be applied to derive geolocation,

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and it does not place requirements on the derived geolocated data'.

This work is a useful treatise summarising the essential characteristics of the various types of earth imagery scanner. There is provision to include other types of image raster collection such as a hard copy scanner.

The ISO/TC 211 work item that introduces Services is ISO DIS 19118 Geographic information - Services. The scope of this standard is: *'Identification and definition of the architecture patterns for service interfaces used for geographic information and definition of the relationships to the Open Systems Environment model. This International Standard presents a geographic services taxonomy and a list of example geographic services placed in the services taxonomy. This International Standard prescribes how to create a platform-neutral service specification, and how to derive platform-specific service specifications that are conformant with this. This International Standard provides guidelines for the selection and specification of geographic services from both platform-neutral and platform-specific perspectives'*. The forward confirms harmonization with the OGC Abstract Specification Topic 12 The Open GIS Service Architecture. The emphasis in this standard is on how to construct a service architecture in the GIS industry so that interoperability can be achieved. It particularly requires the definition of architectures and services at the abstract level. The purpose of this requirement is so that another part of the vision can be followed: the mapping of the defined technology to different distributed computing platforms (DCPs) and achieving interoperability between them. Thus, this is an important standard for GETIS to be referencing, since connection to future and legacy as well as current technology is a requirement.
