BRITISH STANDARD

BS EN ISO 19128:2008

Geographic information — Web map server interface

ICS 35.240.70

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The UK participation in its preparation was entrusted to Technical Committee IST/36, Geographic information.

A list of organizations represented on this committee can be obtained on request to its secretary.

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English Version

Geographic information - Web map server interface (ISO 19128:2005)

Information géographique - Interface de carte du serveur web (ISO 19128:2005)

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Foreword

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This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by July 2008, and conflicting national standards shall be withdrawn at the latest by July 2008.

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The text of ISO 19128:2005 has been approved by CEN as EN ISO 19128:2008 without any modifications.

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Introduction

A Web Map Service (WMS) produces maps of spatially referenced data dynamically from geographic information. This International Standard defines a “map” to be a portrayal of geographic information as a digital image file suitable for display on a computer screen. A map is not the data itself. WMS-produced maps are generally rendered in a pictorial format such as PNG, GIF or JPEG, or occasionally as vector-based graphical elements in Scalable Vector Graphics (SVG) or Web Computer Graphics Metafile (WebCGM) formats.

This International Standard defines three operations: one returns service-level metadata; another returns a map whose geographic and dimensional parameters are well-defined; and an optional third operation returns information about particular features shown on a map. Web Map Service operations can be invoked using a standard web browser by submitting requests in the form of Uniform Resource Locators (URLs). The content of such URLs depends on which operation is requested. In particular, when requesting a map the URL indicates what information is to be shown on the map, what portion of the Earth is to be mapped, the desired coordinate reference system, and the output image width and height. When two or more maps are produced with the same geographic parameters and output size, the results can be accurately overlaid to produce a composite map. The use of image formats that support transparent backgrounds (e.g. GIF or PNG) allows underlying maps to be visible. Furthermore, individual maps can be requested from different servers. The Web Map Service thus enables the creation of a network of distributed map servers from which clients can build customized maps. Illustrative examples of map request URLs and their resulting maps are shown in Annex G.

This International Standard applies to a Web Map Service instance that publishes its ability to produce maps rather than its ability to access specific data holdings. A basic WMS classifies its geographic information holdings into “Layers” and offers a finite number of predefined “Styles” in which to display those layers. This International Standard supports only named Layers and Styles, and does not include a mechanism for user-defined symbolization of feature data.

NOTE The Open Geospatial Consortium (OGC) Styled Layer Descriptor (SLD) specification [6] defines a mechanism for user-defined symbolization of feature data instead of named Layers and Styles. In brief, an SLD-enabled WMS retrieves feature data from a Web Feature Service [7] and applies explicit styling information provided by the user in order to render a map.

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Geographic information — Web map server interface

1 Scope

This International Standard specifies the behaviour of a service that produces spatially referenced maps dynamically from geographic information. It specifies operations to retrieve a description of the maps offered by a server to retrieve a map, and to query a server about features displayed on a map. This International Standard is applicable to pictorial renderings of maps in a graphical format; it is not applicable to retrieval of actual feature data or coverage data values.

2 Conformance

2.1 Conformance classes and requirements

This International Standard defines two conformance classes, one for a basic WMS, and the other for a queryable WMS. Each has two subclasses, one for clients and the other for servers.

2.2 Basic WMS

A basic WMS shall support the basic service elements (see Clause 6), the GetCapabilities operation (see 7.2), and the GetMap operation (see 7.3). To conform to this International Standard, a basic WMS shall satisfy the requirements of A.1 of the Abstract Test Suite in Annex A.

2.3 Queryable WMS

A queryable WMS shall satisfy all the requirements for a basic WMS, and shall also support the GetFeatureInfo operation (see 7.4). To conform to this International Standard, a queryable WMS shall satisfy all requirements of the Abstract Test Suite in Annex A.

3 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 8601:2004, *Data elements and interchange formats — Information interchange — Representation of dates and times*

ISO 19111, *Geographic information — Spatial referencing by coordinates*

ISO 19115:2003, *Geographic information — Metadata*

EPSG (February 2003), *European Petroleum Survey Group Geodesy Parameters*, Lott, R., Ravanas, B., Cain, J., Simonson, G, and Nicolai, R., eds., available at <*http://www.epsg.org/*>

IETF RFC 2045 (November 1996), *Multipurpose Internet Mail Extensions (MIME) Part One: Format of Internet Message Bodies*, Freed, N. and Borenstein, N., eds., available at <*http://www.ietf.org/rfc/rfc2045.txt*>

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IETF RFC 2616 (June 1999), *Hypertext Transfer Protocol – HTTP/1.1*, Gettys, J., Mogul, J., Frystyk, H., Masinter, L., Leach, P., and Berners-Lee, T., eds., available at <*http://www.ietf.org/rfc/rfc2616.txt*>

UCUM, *Unified Code for Units of Measure*, Schadow, G. and McDonald, C.J. (eds.), version 1.5 <*http://aurora.regenstrief.org/UCUM/ucum.html*>

XML 1.0, *Extensible Markup Language (XML) 1.0*, World Wide Web Consortium Recommendation, Bray, T., Paoli, J., Sperberg-McQueen, C.M., and Maler, E., eds., available at <*http://www.w3.org/TR/*>

XML Schema, *XML Schema Part 1: Structures*, World Wide Web Consortium Recommendation, Thompson, H.S., Beech, D., Maloney, M., and Mendelsohn, N., eds., available at <*http://www.w3.org/TR/*>

4 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

4.1
client
software component that can invoke an **operation** from a **server**

4.2
coordinate reference system
coordinate system that is related to the real world by a datum

[ISO 19111]

4.3
coordinate system
set of mathematical rules for specifying how coordinates are to be assigned to points

[ISO 19111]

4.4
geographic information
information concerning phenomena implicitly or explicitly associated with a location relative to the Earth

[ISO 19101]

4.5
interface
named set of **operations** that characterize the behaviour of an entity

[ISO 19119]

4.6
layer
basic unit of **geographic information** that may be requested as a **map** from a **server**

4.7
map
portrayal of **geographic information** as a digital image file suitable for display on a computer screen

4.8
operation
specification of a transformation or query that an object may be called to execute

[ISO 19119]

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4.9
portrayal
presentation of information to humans

[ISO 19117]

4.10
request
invocation of an **operation** by a **client**

4.11
response
result of an **operation** returned from a **server** to a **client**

4.12
server
a particular instance of a service

4.13
service
distinct part of the functionality that is provided by an entity through **interfaces**

[ISO 14252]

4.14
service metadata
metadata describing the **operations** and **geographic information** available at a **server**

5 Abbreviated terms

CDATA	XML Character Data
CRS	Coordinate Reference System
CS	Coordinate System
DCP	Distributed Computing Platform
DTD	Document Type Definition
EPSG	European Petroleum Survey Group
GIF	Graphics Interchange Format
GIS	Geographic Information System
HTTP	Hypertext Transfer Protocol
IANA	Internet Assigned Numbers Authority
IERS	International Earth Rotation Service
IETF	Internet Engineering Task Force
ITRF	International Terrestrial Reference Frame
ITRS	IERS Terrestrial Reference System

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JPEG	Joint Photographic Experts Group
MIME	Multipurpose Internet Mail Extensions
NAD	North American Datum
OGC	Open GIS Consortium
PNG	Portable Network Graphics
RFC	Request for Comments
SVG	Scalable Vector Graphics
UCUM	Unified Code for Units of Measure
URL	Uniform Resource Locator
WebCGM	Web Computer Graphics Metafile
WCS	Web Coverage Service
WFS	Web Feature Service
WGS	World Geodetic System
WMS	Web Map Service
XML	Extensible Markup Language

6 Basic service elements

6.1 Introduction

This clause specifies aspects of Web Map Server behaviour that are independent of particular operations or are common to several operations.

6.2 Version numbering and negotiation

6.2.1 Version number form and value

The Web Map Service (WMS) defines a protocol version number. The version number applies to the XML schema and the request encodings defined in this International Standard. The version number contains three non-negative integers, separated by decimal points, in the form "$x.y$.z". The numbers "y" and "z" shall not exceed 99.

Implementations of this International Standard shall use the value "1.3.0" as the protocol version number.

6.2.2 Version number changes

The protocol version number shall be changed with each revision of this International Standard. The number shall increase monotonically and shall comprise no more than three integers separated by decimal points, with the first integer being the most significant. There may be gaps in the numerical sequence. Some numbers may denote draft versions. Servers and their clients need not support all defined versions, but shall obey the negotiation rules below.

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6.2.3 Appearance in requests and in service metadata

The version number shall appear in at least two places: in the service metadata and in the parameter list of client requests to a server. The version number used in a client's request of a particular server shall be equal to a version number which that server has declared it supports (except during negotiation, as described below). A server may support several versions, whose values clients may discover according to the negotiation rules.

6.2.4 Version number negotiation

A WMS client may negotiate with a server to determine a mutually agreeable protocol version. Negotiation is performed using the GetCapabilities operation (described in 7.2) according to the following rules.

All service metadata shall include a protocol version number and shall comply with the XML DTD or Schema defined for that version. In response to a GetCapabilities request (for which the VERSION parameter is optional) that does not specify a version number, the server shall respond with the highest version it supports. In response to a GetCapabilities request containing a version number that the server implements, the server shall send that version. If the server does not support the requested version, the server shall respond with output that conforms to a version it does support, as determined by the following rules:

— If a version unknown to the server and higher than the lowest supported version is requested, the server shall send the highest version it supports that is less than the requested version.

— If a version lower than any of those known to the server is requested, then the server shall send the lowest version it supports.

— If the client does not support the version sent by the server, it may either cease communicating with the server or send a new request with a different version number that the client does support.

The process may be repeated until a mutually understood version is reached, or until the client determines that it will not or cannot communicate with that particular server.

EXAMPLE 1 Server understands versions 1, 2, 4, 5 and 8. Client understands versions 1, 3, 4, 6, and 7. Client requests version 7. Server responds with version 5. Client requests version 4. Server responds with version 4, which the client understands, and the negotiation ends successfully.

EXAMPLE 2 Server understands versions 4, 5 and 8. Client understands version 3. Client requests version 3. Server responds with version 4. Client does not understand that version or any higher version, so negotiation fails and client ceases communication with that server.

The VERSION parameter is mandatory in requests other than GetCapabilities.

6.3 General HTTP request rules

6.3.1 Introduction

This International Standard defines the implementation of the WMS on a distributed computing platform (DCP) comprising Internet hosts that support the Hypertext Transfer Protocol (HTTP) (see IETF RFC 2616). Thus, the Online Resource of each operation supported by a server is an HTTP Uniform Resource Locator (URL). The URL may be different for each operation, or the same, at the discretion of the service provider. Each URL shall conform to the description in IETF RFC 2616 (section 3.2.2 "HTTP URL") but is otherwise implementation-dependent; only the query portion comprising the service request itself is defined by this International Standard.

HTTP supports two request methods: GET and POST. One or both of these methods may be offered by a server, and the use of the Online Resource URL differs in each case. Support for the GET method is mandatory; support for the POST method is optional.

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6.3.2 Reserved characters in HTTP GET URLs

The URL specification (IETF RFC 2396) reserves particular characters as significant and requires that these be escaped when they might conflict with their defined usage. This International Standard explicitly reserves several of those characters for use in the query portion of WMS requests. When the characters “?”, “&”, “=”, “,” and “+” appear in one of the roles defined in Table 1, they shall appear literally in the URL. When those characters appear elsewhere (for example, in the value of a parameter), they shall be encoded as defined in IETF RFC 2396.

The server shall be prepared to decode any character escaped in this manner, and to decode the “+” character as a space.

Table 1 — Reserved characters in WMS query string

Character	Reserved usage
?	Separator indicating start of query string.
&	Separator between parameters in query string.
=	Separator between name and value of parameter.
,	Separator between individual values in list-oriented parameters (such as BBOX, LAYERS and STYLES in the GetMap request).
+	Shorthand representation for a space character.

6.3.3 HTTP GET

A WMS shall support the “GET” method of the HTTP protocol (IETF RFC 2616).

An Online Resource URL intended for HTTP GET requests is in fact only a URL prefix to which additional parameters are appended in order to construct a valid Operation request. A URL prefix is defined in accordance with IETF RFC 2396 as a string including, in order, the scheme (“http” or “https”), Internet Protocol hostname or numeric address, optional port number, path, mandatory question mark “?”, and optional string comprising one or more server-specific parameters ending in an ampersand “&”. The prefix defines the network address to which request messages are to be sent for a particular operation on a particular server. Each operation may have a different prefix. Each prefix is entirely at the discretion of the service provider.

This International Standard defines how to construct a query part that is appended to the URL prefix in order to form a complete request message. Every WMS operation has several mandatory or optional request parameters. Each parameter has a defined name. Each parameter may have one or more legal values, which are either defined by this International Standard or are selected by the client based on service metadata. To formulate the query part of the URL, a client shall append the mandatory request parameters, and any desired optional parameters, as name/value pairs in the form “name=value&” (parameter name, equals sign, parameter value, ampersand). The “&” is a separator between name/value pairs, and is therefore optional after the last pair in the request string.

When the HTTP GET method is used, the client-constructed query part is appended to the URL prefix defined by the server, and the resulting complete URL is invoked as defined by HTTP (IETF RFC 2616).

Table 2 summarizes the components of an operation request URL when HTTP GET is used.

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Table 2 — Structure of WMS request using HTTP GET

URL component	Description
http://host[:port]/path[?{name[=value]&}]	URL prefix of service operation. [ ] denotes 0 or 1 occurrence of an optional part; {} denotes 0 or more occurrences.
name=value&	One or more standard request parameter name/value pairs as defined for each operation by this International Standard.

6.3.4 HTTP POST

A WMS may support the “POST” method of the HTTP protocol (IETF RFC 2616).

An Online Resource URL intended for HTTP POST requests is a complete URL (not merely a prefix as in the HTTP GET case) that is valid according to IETF RFC 2396 to which clients transmit request parameters in the body of the POST message. A WMS shall not require additional parameters to be appended to the URL in order to construct a valid target for the operation request. When POST is used, the request message is formulated as an XML document.

6.4 General HTTP response rules

Upon receiving a valid request, the server shall send a response corresponding exactly to the request as detailed in Clause 7 of this International Standard, or send a service exception if unable to respond correctly. Only in the case of Version Negotiation (see 6.2.4) may the server offer a differing result. Upon receiving an invalid request, the server shall issue a service exception as described in 6.11.

A server may send an HTTP Redirect message (using HTTP response codes as defined in IETF RFC 2616) to an absolute URL that is different from the valid request URL that was sent by the client. HTTP Redirect causes the client to issue a new HTTP request for the new URL. Several redirects could in theory occur. Practically speaking, the redirect sequence ends when the server responds with a WMS response. The final response shall be a WMS response that corresponds exactly to the original request (or a service exception).

Response objects shall be accompanied by the appropriate Multipurpose Internet Mail Extensions (MIME) type (IETF RFC 2045) for that object. A list of MIME types in common use on the internet is maintained by the Internet Assigned Numbers Authority (IANA) [2]. Allowable types for operation responses and service exceptions are discussed below. The basic structure of a MIME type is a string of the form “type/subtype”. MIME allows additional parameters in a string of the form “type/subtype; param1=value1; param2=value2”. A server may include parameterized MIME types in its list of supported output formats. In addition to any parameterized variants, the server should offer the basic unparameterized version of the format.

Response objects should be accompanied by other HTTP entity headers as appropriate and to the extent possible. In particular, the Expires and Last-Modified headers provide important information for caching; Content-Length may be used by clients to know when data transmission is complete and to efficiently allocate space for results, and Content-Encoding or Content-Transfer-Encoding may be necessary for proper interpretation of the results.

6.5 Numeric and Boolean values

Integer numbers shall be represented in a manner consistent with the specification for integers in XML Schema Datatypes ([8], section 3.3.13). This International Standard shall explicitly indicate where an integer value is mandatory.

Real numbers shall be represented in a manner consistent with the specification for double-precision numbers in XML Schema Datatypes ([8], section 3.2.5). This representation allows for integer, decimal and exponential notations. A real value is allowed in all numeric fields defined by this International Standard unless the value is explicitly restricted to integer.

Positive, negative and zero values are allowed unless explicitly restricted.

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Boolean values shall be represented in a manner consistent with the specification for Boolean in XML Schema Datatypes ([8], section 3.2.2). The values “0” and “false” are equivalent. The values “1” and “true” are equivalent. Absence of an optional value is equivalent to logical false. This International Standard shall explicitly indicate where a Boolean value is mandatory.

6.6 Output formats

The response to a Web Map Service request is always a computer file that is transferred over the Internet from the server to the client. The file may contain text, or the file may represent a map image. As stated in 6.4, the type of the returned file shall be indicated by a MIME type string.

Text output formats are usually formatted as Extensible Markup Language (XML; MIME type text/xml). Text formats are used to convey service metadata, descriptions of error conditions, or responses to queries for information about features shown on a map.

Allowed map formats are either “picture” formats or “graphic element” formats. Picture formats constitute a rectangular pixel array of fixed size. Picture formats include file types such as Graphics Interchange Format (GIF; MIME type “image/gif”), Portable Network Graphics (PNG; MIME type “image/png”), Joint Photographics Expert Group (JPEG; MIME type “image/jpeg”), all of which can be displayed by common Web browsers, and file types such as Tagged Image File Format (TIFF: MIME type “image/tiff”) that may require additional software (beyond a basic Web browser) for display. Graphic element formats constitute a scale-independent description of the graphic elements to be displayed (including points, lines, curves, text and images), such that the size of the display may be modified while preserving the relative arrangement of the graphic elements. Graphic element formats include Scalable Vector Graphics (SVG; MIME type “image/svg+xml”) or Web Computer Graphics Metafile (WebCGM; MIME type “image/cgm;Version=4;ProfileId=WebCGM”) formats.

NOTE 1 SVG is expressed using XML, and could therefore be considered to be a text output format, but for the purposes of this International Standard SVG is considered to be a map format.

NOTE 2 WebCGM is a profile of ISO/IEC 8632.

A server may offer multiple map formats. The formats it offers are enumerated in <Format> elements in its service metadata. Use of a specific format is not required by this International Standard. However, for maps that portray vector features the server should offer at least one format that supports transparency in order that maps may be overlaid without obscuring other maps below (see the discussion about transparency in 7.3.3.9). Also, for ease of use, the server should offer at least one format that can be displayed by common Web browsers without additional software. Based on these considerations, the server should offer at least the PNG format.

6.7 Coordinate systems

6.7.1 Introduction

This International Standard uses two principal classes of Coordinate Systems: a Map CS applicable to the map portrayal generated by the WMS, and a Layer CRS for a Bounding Box applied to the source data. During a portrayal operation, a WMS converts or transforms geographic information from a Layer CRS into a Map CS. In addition, a Layer may have an associated vertical, temporal or other coordinate system.

6.7.2 Map CS

A Map CS is a coordinate reference system for a map produced by a WMS. A WMS map is a rectangular grid of pixels displayed on a computer screen (or a digital file that could be so displayed). The Map CS has a horizontal axis denoted i, and a vertical axis denoted j. i and j shall have only nonnegative integer values. The origin (i,j) = (0,0) is the pixel in the upper left corner of the map; i increases to the right and j increases downward. The Map CS is defined using ISO 19111 terminology in B.2. The Map CS is identified by the label “CRS:1”.

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The usual orientation of the Map CS shall be such that the i axis is parallel to the East-to-West axis of the Layer CRS and increases Eastward, and the j axis is parallel to the North-to-South axis of the Layer CRS and increases Southward. This orientation will not be possible in some cases, as (for example) in an orthographic projection over the South Pole. The convention to be followed is that, wherever possible, East shall be to the right edge and North shall be toward the upper edge of the Map CS.

The WIDTH and HEIGHT parameters used in the GetMap request (see 7.3.3.8) and by inclusion in the GetFeatureInfo request (7.4.3.3) correspond to i and j as follows:

— WIDTH denotes the size of the map image in pixels along the i axis (that is, WIDTH-1 is the maximum value of i).

— HEIGHT denotes the size of the map image in pixels along the j axis (that is, HEIGHT-1 is the maximum value of j).

The *I* and *J* parameters used in the GetFeatureInfo request (see 7.4.3.7) denote integer values along the i and j axes, respectively, of the Map CS.

6.7.3 Layer CRS

6.7.3.1 Introduction

A Layer CRS is a horizontal coordinate reference system for the geographic information that serves as the source for a map. As discussed below, many Layer CRSs are possible. A Layer CRS appears in the following entities relevant to the WMS:

— the <BoundingBox> element in the service metadata (7.2.4.6.8);

— the CRS parameter in the GetMap request (7.3.3.5);

— the CRS parameter in the map request part of the GetFeatureInfo request (7.4.3.3).

A WMS must support at least one CRS, and maps from multiple servers may be overlaid only if all the selected servers have at least one CRS in common. This International Standard does not mandate support for any particular Layer CRS(s). Instead, it only defines how CRSs are identified and discusses several optional Layer CRSs, in this clause and in Annex B. Map providers may support the CRSs that are most useful and appropriate to their geographic locale or information community. To maximize interoperability among servers, providers should also support geographic coordinates by geocentric coordinate systems such as “CRS:84” (see 6.7.3.2), “EPSG:4326” (see 6.7.3.3) or other ITRF-based systems.

Every Layer CRS has an identifier that is a character string. Two types of Layer CRS identifiers are permitted: “label” and “URL” identifiers:

— **Label**: The identifier includes a namespace prefix, a colon, a numeric or string code, and in some instances a comma followed by additional parameters. This International Standard defines three namespaces: CRS, EPSG and AUTO2, as discussed below.

— **URL**: The identifier is a fully-qualified URL that references a publicly-accessible file containing a definition of the CRS that is compliant with ISO 19111.

The Layer CRS has two axes, denoted x and y. The x axis is the first axis in the CRS definition, the y axis is the second axis. Depending on the particular CRS, the x axis may or may not be oriented West-to-East, and the y axis may or may not be oriented South-to-North. The WMS portrayal operation shall account for axis order, origin and direction in the Layer CRS when projecting geographic information from a Layer CRS to the Map CS.

Coordinates shall be listed in the order defined by the CRS and shall be mapped appropriately to the Map CS i and j axes, swapping axis order as needed during the projection operation. Many projected coordinate

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reference systems have an axis and coordinate order other than easting, northing. For example, the Uniform Coordinate System used in Finland (EPSG:2393) orders northing before easting. EPSG geographic coordinate reference systems follow ISO 6709 and always list latitude before longitude.

Most coordinate reference systems are orientated with one axis positive east (easting) and the other axis positive north (northing). These map conveniently to the bounding box i and j axes, respectively. However, some CRSs have coordinates incrementing in other directions. For example, the Hartebeesthoek94/Lo25 system used in South Africa (EPSG:2051) has axes with coordinates incrementing to the west and south. Tests for valid bounding box areas shall recognise and account for the positive orientation of the CRS axes.

In a geographic CRS, latitude shall have values within the range [-90, 90] and longitude shall have values within the range [-180, 180] degrees or equivalent if the CRS definition is in other units. See 7.3.5 regarding the projection of Layer CRS that is a geographic CRS into the Map CS. When the CRS code specifies a geographic 2D coordinate reference system with axes in units other than degrees or in a degree representation other than decimal degrees the representation shall be converted to decimal degrees.

NOTE The use of geographic CRSs with axis order of longitude before latitude differs from historical convention. Users in the international aviation and marine sectors may expect latitude to be before longitude, and a different coordinate display may have safety implications, especially in an emergency response situation. Although this International Standard does not specify human user interfaces, developers of user interfaces for WMSs are cautioned that all references to latitude and longitude, for example user input of bounding box or readout of cursor coordinates, should show latitude before longitude.

6.7.3.2 CRS namespace for CRS

The “CRS” namespace prefix refers to coordinate reference systems that are defined in Annex B of this International Standard. These definitions are in the form specified by ISO 19111. Geographic CRSs in the “CRS” namespace are defined in Annex B for the WGS 84, NAD27 and NAD83 datums.

A “CRS” CRS label comprises the “CRS” prefix, the colon, and a numeric or string code.

EXAMPLE “CRS:84” refers to WGS 84 geographic longitude and latitude expressed in decimal degrees, with longitude ranging from –180 degrees to +180 degrees and latitude from –90 degrees to +90 degrees.

6.7.3.3 EPSG namespace for CRS

The “EPSG” namespace prefix refers to the European Petroleum Survey Group geodetic dataset (EPSG), which defines numeric identifiers (the EPSG “CRS code,” corresponding to the field “COORD_REF_SYS_CODE” in the EPSG dataset) for many common coordinate reference systems. Defining geodetic, map projection and coordinate reference system data is related to each CRS identifier.

An “EPSG” CRS label comprises the “EPSG” prefix, the colon, and a numeric code.

EXAMPLE EPSG:4326 refers to WGS 84 geographic latitude, then longitude. That is, in this CRS the x axis corresponds to latitude, and the y axis to longitude.

NOTE EPSG geographic coordinate reference systems with axes of “degree – vendor-defined representation” are taken in this International Standard to be in decimal degrees.

6.7.3.4 AUTO2 namespace for CRS

The “AUTO2” namespace is used for “automatic” coordinate reference systems; that is, for a class of CRSs that include a user-selected centre of projection. Several “AUTO2” CRSs are defined in Annex B.

A complete “AUTO2” CRS label comprises the “AUTO2” namespace prefix, a numeric CRS identifier from the AUTO2 namespace, a number indicating what conversion factor to apply to convert between bounding box units and AUTO2 CRS units, and values for the central longitude and latitude in degrees:

```
AUTO2:auto_crs_id,factor,lon0,lat0
```


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The conversion factor shall be nonzero and positive. If factor=1, then the units of the BBOX values are the same as those stated in the CRS definition. If factor is not 1, then factor is the ratio of BBOX units to CRS units. In a GetMap request, the complete AUTO2 CRS is specified, including longitude, latitude and units. In service metadata, the longitude, latitude and units variables are omitted because they are chosen by the client in a request for an AUTO2 CRS.

EXAMPLE 1 A server indicates that it supports Auto Orthographic CRS by including the element "`<CRS>AUTO2:42003</CRS>`" in its service metadata. A client may issue a GetMap request for a map in this CRS, with bounding box in meters, centered at 100 degrees West longitude and 45 degrees North latitude, using the parameter "`CRS=AUTO2:42003,1,-100,45`".

EXAMPLE 2 Same request as in example 1, but with conversion factor allowing bounding box in U.S. feet: "`CRS=AUTO2:42003,0.3048006096012192,-100,45`".

6.7.3.5 Geographic information with undefined CRS

A server may offer two-dimensional geographic information whose precise spatial reference is undefined. For example, a hand-drawn historical map may represent an area of the Earth but not employ a modern coordinate reference system, and an aerial photograph may not be precisely georeferenced. Such types of graphical information shall be treated as an image, and the Map CS label "CRS:1" shall be used when declaring the Layer CRS of such an object. Clients should not attempt to overlay a layer for which CRS=CRS:1 with another layer.

6.7.4 Bounding boxes

Bounding box values specify the portion of the Earth to be mapped through two pairs of coordinates in a specified Layer CRS. The first pair specifies the minimum coordinate values in the Layer CRS, the second specifies maximum coordinate values. Although for most CRSs with axes incrementing to the east and north this would be the lower left and upper right corners of the area of interest, the minimum and maximum values might be at other points in some instances. For example, when using geographic coordinates to describe an area over a pole, or when the layer CRS axes increment in directions other than east and north. The order in which ordinates in each pair are listed shall be as defined by the Layer CRS; x corresponds to the first axis in the Layer CRS and y to the second. This order may not coincide with the Map CS axis order i, j. The bounding box coordinate values shall be in the units defined for the Layer CRS.

NOTE The use of two corner points to specify the map region is not the only possible method in theory. Other possibilities include specifying a central point and a radius, or a central point and a zoom level or scale. Some services that use mapping (e.g. location-based services) may find a formalism based on the central point more appropriate. This International Standard is not intended to preclude other service types from using other map region definitions internally or in client interactions. For most coordinate reference systems, it is a simple mathematical operation to transform between corner-point and central-point methods. Thus, for example, user input of a central point and radius could be converted to a two-point bounding box when requesting a map from a WMS that implements this International Standard.

Bounding Box values appear in the following entities relevant to the WMS:

— the <BoundingBox> element in the service metadata (7.2.4.6.8);

— the BBOX parameter in the GetMap request (7.3.3.6);

— the BBOX parameter in the map request part of the GetFeatureInfo request (7.4.3.3).

A Bounding Box shall not have zero area.

EXAMPLE 1 A <BoundingBox> metadata element for a Layer representing the entire Earth in the CRS:84 Layer CRS would be written as
`<BoundingBox CRS="CRS:84" minx="-180" miny="-90" maxx="180" maxy="90">`.
A BBOX parameter requesting a map of the entire Earth would be written in this CRS as
`BBOX=-180,-90,180,90`.

EXAMPLE 2 A <BoundingBox> representing the entire Earth in the EPSG:4326 Layer CRS would be written as
`<BoundingBox CRS="EPSG:4326" minx="-90" miny="-180" maxx="90" maxy="180">`.
A BBOX parameter requesting a map of the entire Earth would be written in this CRS as
`BBOX=-90,-180,90,180`.

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6.7.5 Vertical CRS

Some geographic information may be available at multiple elevations (for example, ozone concentrations at different heights in the atmosphere). A WMS may announce available elevations in its service metadata, and the GetMap operation includes an optional parameter for requesting a particular elevation. A single elevation or depth value is a number whose units, and the direction in which ordinates increment, are declared through a one-dimensional vertical CRS. Depending on the context, elevation values may appear as a single value, a list of values, or an interval, as specified in Annex C.

A server may declare at most one vertical CRS for each layer. For the purposes of this International Standard, the horizontal and vertical CRSs are treated as independent metadata elements and request parameters.

A request for a map at a specific elevation includes an elevation value but does not include the vertical CRS identifier (the horizontal CRS, which is included along with the horizontal bounding box in the request parameters). When providing elevation information, a server should declare a default value in service metadata, and a server shall respond with the default value if one has been declared and the client request does not include a value.

Two types of Vertical CRS identifiers are permitted: “label” and “URL” identifiers:

— **Label**: The identifier includes a namespace prefix, a colon, and a numeric or string code. B.6 defines an optional vertical CRS labelled “CRS:88” based on the North American Vertical Datum 1988. If the namespace prefix is “EPSG”, then the vertical CRS is one of those defined in the European Petroleum Survey Group database.

— **URL**: The identifier is a fully-qualified Uniform Resource Locator that references a publicly-accessible file containing a definition of the CRS that is compliant with ISO 19111.

If the height is the vertical component of a 3-dimensional CRS, the Vertical CRS identifier shall be that of the 3-dimensional CRS.

6.7.6 Temporal CS

Some geographic information may be available at multiple times (for example, an hourly weather map). A WMS may announce available times in its service metadata, and the GetMap operation includes a parameter for requesting a particular time. The format of a time string is specified in Annex D. Depending on the context, time values may appear as a single value, a list of values, or an interval, as specified in Annex C. When providing temporal information, a server should declare a default value in service metadata, and a server shall respond with the default value if one has been declared and the client request does not include a value.

6.7.7 Other coordinate systems

Some geographic information may be available at other dimensions (for example, satellite images in different wavelength bands). The dimensions other than the four space-time dimensions are referred to as “sample dimensions”. A WMS may announce available sample dimensions in its service metadata, and the GetMap operation includes a mechanism for requesting dimensional values. Each sample dimension has a Name and one or more valid values. The declaration and use of sample dimensions are specified in C.3.3.

6.8 Request parameter rules

6.8.1 Parameter ordering and case

Parameter names shall not be case sensitive, but parameter values shall be. In this International Standard, parameter names are typically shown in uppercase for typographical clarity, not as a requirement.

Parameters in a request may be specified in any order.

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When request parameters are duplicated with conflicting values, the response from the server may be undefined. This International Standard does not mandate which of the duplicated values sent by the client are to be used by the server.

A WMS shall be prepared to encounter additional request parameters that are not part of this International Standard. In terms of producing results per this International Standard, a WMS shall not require such parameters.

6.8.2 Parameter lists

Parameters consisting of lists (for example, BBOX, LAYERS and STYLES in WMS GetMap) shall use the comma (“,”) as the separator between items in the list. Additional white space shall not be used to delimit list items. If a list item value includes a space or comma, it shall be escaped using the URL encoding rules (see 6.3.2 and IETF RFC 2396).

In some lists, individual entries may be empty, and shall be represented by the empty string (“”). Thus, two successive commas indicate an empty item, as does a leading comma or a trailing comma. An empty list (“”) shall be interpreted either as a list containing no items or as a list containing a single empty item, depending on context.

6.9 Common request parameters

6.9.1 VERSION

The VERSION parameter specifies the protocol version number. The format of the version number, and version negotiation, are described in 6.2.

6.9.2 REQUEST

The REQUEST parameter indicates which service operation is being invoked. The value shall be the name of one of the operations offered by the server.

6.9.3 FORMAT

The FORMAT parameter specifies the output format of the response to an operation.

A WMS may offer only a subset of the formats known for that type of operation. The server shall advertise in its service metadata those formats it does support and shall accept requests for any format it advertises. A server may optionally offer a new format not previously offered by other instances, with the recognition that clients shall not be required to accept or process an unknown format. If a request contains a format not offered by a particular server, the server shall respond with the default format for that operation if one has been defined, or throw a service exception (with code “InvalidFormat”) if no default has been defined.

A client may accept only a subset of the formats known for that type of operation. If a client and server do not support any mutually agreeable formats, the client may, at its discretion, cease communicating with that server, or search for an intermediary service provider that performs format conversion, or allow the user to choose other disposition methods (e.g. saving to local storage or passing to a helper application).

Formats are expressed in both service metadata and in operation requests using MIME types. Each operation has a distinct list of supported formats. Some formats may be offered by several operations, and are then duplicated as needed in each list.

6.9.4 EXCEPTIONS

The EXCEPTIONS request parameter states the format in which to report errors (see 6.11).

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6.9.5 Extended capabilities and operations

The Web Map Service allows for optional extended capabilities and operations. Extensions may be defined within an information community when needed for additional functionality or specialization. A generic client shall not be required or expected to make use of such extensions. Extended capabilities or operations shall be defined when necessary by providing instances of the abstract <_ExtendedCapabilities> or <_ExtendedOperations> elements in the service metadata schema in Annex E. Extended capabilities provide additional metadata about the service, and may or may not enable optional new parameters to be included in operation requests. Extended operations allow additional operations to be defined.

A server shall produce a valid response to the operations defined in this International Standard, even if parameters used by extended capabilities are missing or malformed (*i*.e. the server shall supply a default value for any extended capabilities it defines), or if parameters are supplied that are not known to the server.

Service providers shall choose extension names with care to avoid conflicting with standard metadata fields, parameters and operations.

6.10 Service result

The return value of a valid Service request shall correspond to the type requested in the FORMAT parameter. In an HTTP environment, the Content-type header of the response shall be exactly the MIME type given in the valid request.

6.11 Service exceptions

Upon receiving a request that is invalid according to this International Standard, the server shall issue a service exception report. The service exception report is meant to describe to the client application or its human user the reason(s) that the request is invalid. The EXCEPTIONS parameter in a request indicates the format in which the client wishes to be notified of service exceptions. The allowed service exception formats are defined for each operation below.

Errors may arise in software modules other than those which implement the WMS, and may result in exception messages other than those defined by this International Standard. For example, when an error condition occurs in the local computing environment of the WMS server instance (e.g. out of memory or disk space), the server may be unable to process the WMS request and may issue an error message. Or, upon receiving a request that is invalid according to the rules of the Distributed Computing Platform in use, the server may issue a service exception of a type valid in that DCP (e.g. if the URL prefix is incorrect, an HTTP 404 status code (IETF RFC 2616) may be sent).

7 Web Map Service operations

7.1 Introduction

The three operations defined for a WMS are GetCapabilities, GetMap, and GetFeatureInfo. GetFeatureInfo is optional. This clause specifies the implementation and use of these WMS operations in the Hypertext Transfer Protocol (HTTP) Distributed Computing Platform (DCP).

7.2 GetCapabilities (mandatory)

7.2.1 General

The purpose of the mandatory GetCapabilities operation is to obtain service metadata, which is a machine-readable (and human-readable) description of the server's information content and acceptable request parameter values.

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7.2.2 GetCapabilities request overview

The general form of a WMS request is defined in 6.3.3 and 6.3.4. When making the GetCapabilities request of a WMS server, which may offer other service types as well, it is necessary to indicate that the client seeks information about the Web Map Service in particular. Thus, the SERVICE parameter of the request shall have the value “WMS” as shown in Table 3.

Table 3 — The parameters of a GetCapabilities request URL

Request parameter	Mandatory/optional	Description
VERSION=version	O	Request version
SERVICE=WMS	M	Service type
REQUEST=GetCapabilities	M	Request name
FORMAT=MIME_type	O	Output format of service metadata
UPDATESEQUENCE=string	O	Sequence number or string for cache control

7.2.3 Request parameters

7.2.3.1 FORMAT

The optional FORMAT parameter states the desired format of the service metadata. Supported values for a GetCapabilities request on a WMS server are listed in one or more <Request><GetCapabilities><Format> elements of its service metadata. Every server shall support the default text/xml format defined in Annex A. Support for other formats is optional. The entire MIME type string in <Format> is used as the value of the FORMAT parameter. In an HTTP environment, the MIME type shall be set on the returned object using the HTTP Content-type entity header. If the request specifies a format not supported by the server, the server shall respond with the default text/xml format.

7.2.3.2 VERSION

The optional VERSION parameter, and its use in version negotiation, is defined in 6.2.

7.2.3.3 SERVICE

The mandatory SERVICE parameter indicates which of the available service types at a particular server is being invoked. When invoking GetCapabilities on a WMS that implements this version of the International Standard or a later one, the value “WMS” shall be used.

7.2.3.4 REQUEST

The nature of the mandatory REQUEST parameter is defined in 6.9.2. To invoke the GetCapabilities operation, the value “GetCapabilities” shall be used.

7.2.3.5 UPDATESEQUENCE

The optional UPDATESEQUENCE parameter is for maintaining cache consistency. Its value can be either an integer, or a string that represents a timestamp in ISO 8601:2004 format (see Annex D), or any other string. The server may include an UpdateSequence value in its service metadata. If present, this value should be increased when changes are made to the Capabilities (e.g. when new maps are added to the service). The client may include this parameter in its GetCapabilities request. The response of the server based on the presence and relative value of UpdateSequence in the client request and the server metadata shall be according to Table 4.

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Table 4 — Use of UpdateSequence parameter

Client request UpdateSequence value	Server metadata UpdateSequence value	Server response
none	any	most recent service metadata
any	none	most recent service metadata
equal	equal	Exception: code=CurrentUpdateSequence
lower	higher	most recent service metadata
higher	lower	Exception: code=InvalidUpdateSequence

7.2.4 GetCapabilities response

7.2.4.1 Introduction

When invoked on a WMS, the response to a GetCapabilities request shall be an XML document containing service metadata formatted according to the XML Schema in E.1. The schema specifies the mandatory and optional content of the service metadata and how the content is formatted. The XML document shall contain a root element named WMS_Capabilities in the "*http://www.opengis.net/wms*" namespace. This element shall contain an XML Schema instance schemaLocation attribute that binds the "*http://www.opengis.net/wms*" namespace to the schema in E.1. The schema bound to the root attribute may be a copy of the schema in E.1 instead of the master copy at the URL stated in the annex provided none of the normative content of the schema is changed. The schema copy shall be located at a fully-qualified and accessible URL to permit XML validating software to retrieve it. The response shall be valid according to XML Schema validation rules.

A server may comply with other published or experimental protocol versions, in which case it shall support version negotiation as described in 6.2.

7.2.4.2 Names and titles

A number of elements have both a <Name> and a <Title>. The Name is a text string used for machine-to-machine communication while the Title is for the benefit of humans. For example, a dataset might have the descriptive Title "Maximum Atmospheric Temperature" and be requested using the abbreviated Name "ATMAX".

7.2.4.3 General service metadata

The first part of the service metadata is a <Service> element providing general metadata for the server as a whole. It shall include a Name, Title, and Online Resource URL. Optional service metadata includes Abstract, Keyword List, Contact Information, Fees, Access Constraints, and limits on the number of layers in a request or the output size of maps.

The Service Name shall be "WMS" in the case of a WMS.

The Service Title is at the discretion of the provider, and should be brief yet descriptive enough to identify this server in a menu with other servers.

The Abstract element allows a descriptive narrative providing more information about the enclosing object.

The OnlineResource element within the Service element may be used to refer to the web site of the service provider. There are other OnlineResource elements used for the URL prefix of each supported operation (see below).

A list of keywords or keyword phrases describing the server as a whole should be included to help catalogue searching. Each keyword may be accompanied by a "vocabulary" attribute to indicate the defining authority for that keyword. One "vocabulary" attribute value is defined by this International Standard: the value

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“ISO 19115:2003” refers to the metadata topic category codes defined in ISO 19115:2003, B.5.27; information communities may define other “vocabulary” attribute values. No particular vocabulary is mandated by this International Standard.

Contact Information should be included.

The optional <LayerLimit> element in the service metadata is a positive integer indicating the maximum number of layers a client is permitted to include in a single GetMap request. If this element is absent, the server imposes no limit.

The optional <MaxWidth> and <MaxHeight> elements in the service metadata are positive integers indicating the maximum width and height values that a client is permitted to include in a single GetMap request. If either element is absent the server imposes no limit on the corresponding parameter.

The optional elements <Fees> and <AccessConstraints> may be omitted if they do not apply to the server. If either of those elements is present, the reserved word “none” (case-insensitive) shall be used if there are no fees or access constraints, as follows: <Fees>none</Fees>, <AccessConstraints>none</AccessConstraints>. When constraints are imposed, no precise syntax has been defined for the text content of these elements, but client applications may display the content for user information and action.

7.2.4.4 Capability metadata

The <Capability> element of the service metadata names the actual operations that are supported by the server, the output formats offered for those operations, and the URL prefix for each operation. The XML schema includes placeholders for Distributed Computing Platforms other than HTTP, but currently only the HTTP platform is defined.

7.2.4.5 Layers and styles

The most critical parts of the WMS service metadata are the Layers and Styles it defines. The geographic information content offered for portrayal by a WMS server is organized into “layers”: metadata about the content is subdivided into descriptions of each layer, and a request for a map names one or more layers. The terms “layer” and “map” are defined in Clause 4; the relationship between them in the context of this International Standard is that a map is the result of a request to portray information represented by a layer.

The Web Map Service provider decides what information to include, exclude or aggregate in each layer. However, each layer should be documented in accordance with ISO 19115 or FGDC-STD-001-1998 [1], and a link to that metadata should be provided in the <MetadataURL> element defined below.

Each available map is advertised by a <Layer> element in the service metadata. Conceptually, each Layer is a distinct entity. However, as a means of classifying and organizing layers, and as a means of reducing the size of the service metadata, a single parent Layer may enclose any number of additional layers, which may be hierarchically nested as desired. Some properties defined in a parent layer are inherited by the children it encloses. These inherited properties may be either redefined or added to by the child. Subclause 7.2.4.8 summarizes whether or how each property is inherited.

A server shall include at least one <Layer> element for each map layer offered. If desired, layers may be repeated in different categories (*i*.e. enclosed in more than one parent <Layer>) when relevant.

A list of keywords or keyword phrases describing each layer should be included to help catalogue searching. Each keyword may be accompanied by a “vocabulary” attribute to indicate the defining authority for the keyword (see 7.2.4.3).

No controlled vocabulary of Layer and Style Names or Titles is defined by this International Standard, so they may be chosen at the discretion of the service provider organization or information community.

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7.2.4.6 Layer properties

7.2.4.6.1 Introduction

The <Layer> element can enclose child elements providing metadata about the Layer. The meanings of those metadata elements are defined in this subclause. The values of some of these elements are inherited by subsidiary layers as defined in 7.2.4.8.

Some of the metadata values, and additional metadata, may be available in ISO 19115 or FGDC-STD-001-1998 [1] format as referenced via the <MetadataURL> element defined below. Table 5 shows the relationship between Layer Properties in this International Standard and ISO 19115 metadata elements. When documenting layers with ISO 19115 metadata, service providers should ensure that fields listed as equivalent in Table 5 have identical values in the full 19115 and in the summary 19128 layer properties.

Table 5 — Relationship between ISO 19128 and ISO 19115 metadata fields

ISO 19128 layer property	ISO 19115 Metadata element	Relationship
Title	CI_Citation.title	equivalent
Abstract	MD_DataIdentification.abstract	equivalent
Keyword element in KeywordList	MD_TopicCategoryCode	equivalent if “vocabulary” attribute of 19128 <Keyword> element is “ISO 19115:2003”. Other vocabularies are permitted by 19128.
EX_GeographicBoundingBox	EX_GeographicBoundingBox	equivalent
CRS	MD_CRS	Value of CRS in 19128 is a text string that identifies a coordinate reference system defined by another authority. Value of MD_CRS in 19115 is a list of projection, ellipsoid and datum identifiers.
BoundingBox	EX_BoundingPolygon	19128:BoundingBox is strictly a box (lower left and upper right corners in a specified CRS). 19115:EX_BoundingPolygon may be a polygonal boundary.
Attribution	CI_ResponsibleParty	Title element of 19128:Attribution is equivalent to organisationName element of 19115: CI_ResponsibleParty. Other elements of 19128:Attribution have no equivalent in 19115.
Identifier and AuthorityURL	CI_Citation.identifier	The value of 19128:Identifier is equivalent to 19115:CI_Citation.identifier.code. 19128:AuthorityURL contains only the URL of the authority for a namespace, and is equivalent to 19115: CI_Citation.identifier.citation.citedResponsibleParty. contactInfo.onlineResource. 19115 allows a fuller description of the namespace authority.
DataURL	MD_metadata.dataSetURI	equivalent

7.2.4.6.2 Title

A <Title> is mandatory for all layers; it is a human-readable string for presentation in a menu. The Title is not inherited by child Layers.

7.2.4.6.3 Name

If, and only if, a layer has a <Name>, then it is a map layer that can be requested by using that Name in the LAYERS parameter of a GetMap request. A Layer that contains a <Name> element is referred to as a “named

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