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Editors: Andreas Poth; Markus U. Müller

## Web Coordinate Transformation Service Implementation Specification

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## i. Preface

This document describes the OGC Web Coordinate Transformation Service (WCTS) operations. It is issued as a public OGC discussion paper to stimulate feedback from the GI community into the further development of the document. It uses for description of coordinate reference systems and transformations XML-Schemas derived by converting the DTDs from OGC document 01-014r5 with the help of XML Spy software. At the moment the CRS SIG of the OGC develops XML Schemas for coordinate systems and coordinate transformations and also an XML based CRS Registry. As soon as the relevant XML-Schemas are supplied by the OGC they will replace the ones used so far and possibilities for using the CRS registry by a WCTS will be analysed.

Most geo-spatial data are stored in different coordinate reference systems (CRS). To enable services to use data from different sources stored in different CRS each service has to access a transformation service. At the moment each OGC web service has to access its own transformation implementation or access a service via COM, CORBA or RMI as defined in „Coordinate Transformation Services Implementation Specification“ (CTS) [REF 1].

To offer the largest amount of interoperability and a standardized access to the transformations of CRS in a general way through the inter-/intranet this specification defines web service interfaces for performing transformations of geo-spatial data from one CRS to another.

To do this a WCTS shall be able to handle the following requests:

1. Which input and output data formats are supported?
2. Which CRSs are known by the WCTS as source and target CRS of a transformation?
3. Which transformations are known by the WCTS? This is a necessary information because in many cases there exists more than one way to transform coordinates from one CRS to another.
4. Is the WCTS capable to use user defined CRS and/or transformations?
5. Is the transformation between two CRS possible?
6. Which ‘transformation steps’ will be performed to transform a coordinate from one CRS to another?

7. Performing a transformation from one CRS to another.

ii. Submitting organizations

This discussion paper is being submitted by the following organization:

lat/lon

Meckenheimer Allee 176

53115 Bonn

Germany

iii. Submission contact points

All questions regarding this submission should be directed to the editors or the submitters:

| CONTACT          | COMPANY | ADDRESS   | PHONE/FAX             | EMAIL                |
|------------------|---------|---|-----------------------|----------------------|
| Andreas Poth     | lat/lon | Meckenheimer<br>Allee 176, 53115<br>Bonn, Germany | ++49 +228 73<br>9666  | poth@lat-lon.de      |
| Markus U. Müller | lat/lon | Meckenheimer<br>Allee 176, 53115<br>Bonn, Germany | ++49 +40<br>428453476 | m.mueller@lat-lon.de |

iv. Revision history

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| 2002-07-26 | 0.0.1   | Andreas<br>Poth  |                    | initial version   |
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| 2002-08-14 | 0.0.3   | Andreas<br>Poth  | 6-11               | chapter content slightly modified;<br>schema definitions changed; example |



|            |       |                  |      |   |
|------------|-------|------------------|------|---|
|            |       | Poth             |      | requests and responses added  |
| 2002-09-15 | 0.0.4 | Markus<br>Müller | i, 3 | included changes requested by CRS SIG<br>for public discussion paper status |

## v. Changes to the OpenGIS Abstract Specification

No further revisions to the OGC Abstract Specification are required.

## Foreword

Attention is drawn to the possibility that some of the elements of this standard may be the subject of patent rights. Open GIS Consortium Inc. shall not be held responsible for identifying any or all such patent rights. However, to date, no such rights have been claimed or identified.

This version of the specification cancels and replaces all previous versions.

## Normative Annexes

Annexes A and B are normative.

## 0 Introduction

Transformation of geo-spatial data from one CRS to another is a frequent requirement when integrating data from different sources into one application process. But not all applications – we believe most of them – are not capable to do this. The following use cases demonstrate how a web based transformation service can solve this problem.

### 0.1 Use Cases (Informative)

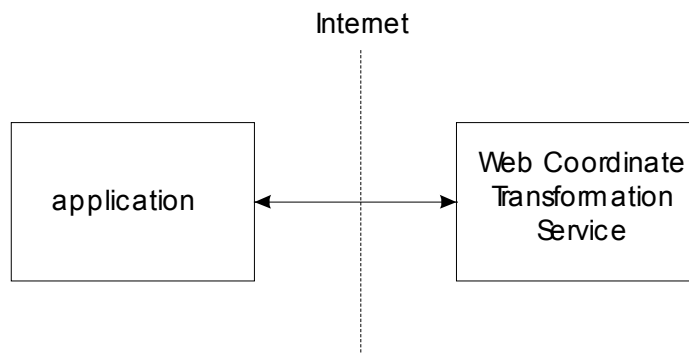
This chapter describes several use cases that will clarify the requirements to a WCTS and their realisation within this specifications.

The base of all use cases is the following scenario:

There is a map to create that uses EPSG:4326 as CRS. The borders of the Federal Republic of Germany (layer 1), the major rivers of the Federal Republic of Germany (layer 2) and the largest cities of the Federal Republic of Germany (layer 3) shall be used. The borders of the Federal Republic of Germany are available in EPSG:31467 (Gauß-Krüger band 3). The major rivers are stored in EPSG:4230 (International 1924) and the largest cities in EPSG:23032 (UTM band 32)

#### 0.1.1 Desktop Application

The term „Desktop Application” describes a GI-application that is running stand-alone on a PC and that accesses the data it uses through a file system. It is assumed that the application is allowed to access a network (intra-/internet) where a WCTS is available. It is also assumed that all layers defined within the scenario are available through the file system (as ESRI-shapefiles for example).



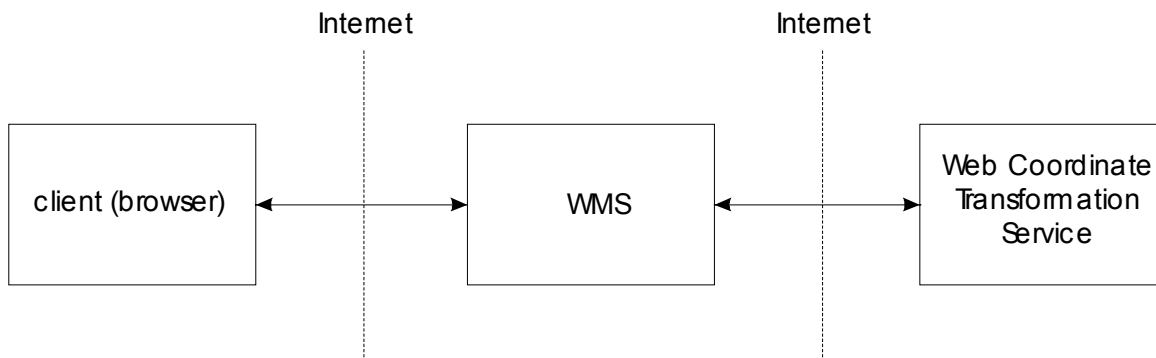
**Fig. 1 use case 1: application - WCTS interaction**

The following steps have to be performed at this use case:

1. The application defines a new map with the target CRS.
2. The application loads layer 1 and recognises that coordinates are not stored in EPSG:4326.
3. The application connects the WCTS through the network and requests its capabilities. Using the capabilities the application evaluates if a transformation from EPSG:31467 to EPSG:4326 can be performed by the WCTS. (This can also be done by sending an IsTransformable request to the WCTS).
4. The application sends the geo-spatial data assigned to layer 1 to the WCTS requesting their transformation to EPSG:4326.
5. The WCTS sends the transformed geometries back to the application.
6. Steps 2 to 5 will be repeated for layer 2 and 3.
7. The application will render the map.

### 0.1.2 WMS

It is assumed that the map defined above will be requested by a client through a network using a valid WMS request. Like in use case 1 it is also assumed that all required data are stored in independent sources that can be accessed by the WMS directly (integrated WMS).



**Fig. 2 use case 2: WMS - WCTS interaction**

The sequence of steps to perform is similar to use case 1.

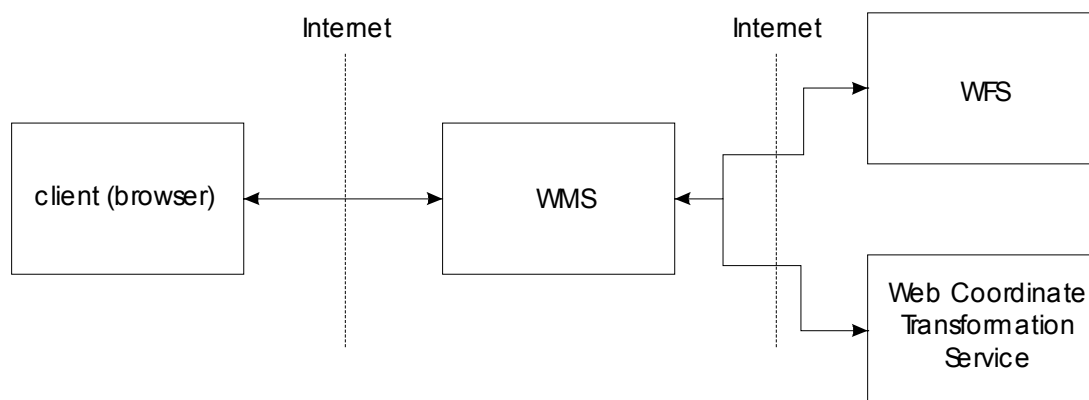
First, however, the client must inquire the WMS (Capabilities Request) whether it can render the map in the desired coordinate reference system. Afterwards the map, as described in use case 1, will be rendered and passed to the client (web browser) via the inter-/intranet.

required steps are:

1. The client defines the parameters for a new map.
2. The client posts a GetMap request to a WMS.
3. The WMS states that the requested layer is not present yet in the correct CRS.
4. The WMS already knows that the WCTS offers the necessary transformation; it therefore sends the data of the first layer for transformation to the WCTS.
5. Step 4 will be repeated for layer 2 and 3.
6. The WMS renders the map and sends it back to the client (web browser)

### 0.1.3 Service Chain

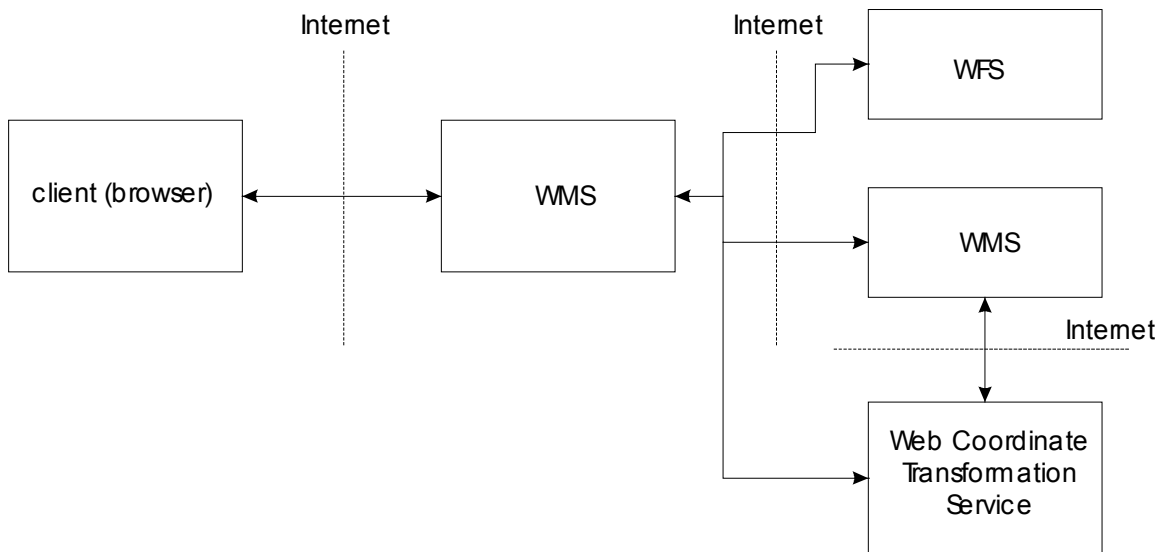
The requirements correspond to those of use case 2; but the renderable data are not offered directly by the WMS. Therefore the WMS must request them via the Internet from a WFS (→ component WMS). This supplies the data in the CRS specified above.



**Fig. 3 use case 3: WMS - WFS - WCTS interaction**

There are a few changes in the expiration of processing compared with use case 2. After the WMS received the request for the production of a map, it requests the necessary data from the WFS. It has to be considered that the WFS is not able to supply the data in the requested CRS (the indication of a target system is not intended in the getFeature Request of the current WFS specifications). After the WMS received the data, it calls the WCTS for transformation of the geometries to EPSG:4326. The remaining steps will be performed as described above.

In principle the model is expandable for further levels e.g. in the case of a cascading WMS or a service chain.



**Fig. 4 use case 3: service chain**

It must be considered that to the WMS addressed through the cascade already must supply the requested Layer in the target CRS, since the transformation of a raster image would be too expensive and the result possibly does not correspond to expectations (e.g. by substantial distortions of the labeling).

# Web Coordinate Transformation Service Implementation Specification

## 1 Scope

This standard specifies the transformations of geo-spatial coordinates from one Coordinate Reference System (CRS) into another by means of a Web Service. Frequently geospatial data are accessible only in one coordinate references system. If geo-spatial data from different sources shall be processed together this is only possible if all relevant data are available in the same reference system. If this is not the case, the data must be transformed into a uniform CRS.

Not each service and/or not each client possesses the ability to transform geo-spatial coordinates from one CRS o another. In practice this makes the realisation of distributed, interoperable GI systems frequently more difficult or impossible.

This specification describes a Web Service based on the OGC CTS implementation specification, which allows applications and other Web Services to transform geo-spatial coordinates from one CRS into another. Transformations shall both take place between CRS that are known by the WCTS and between CRS, which are defined by the user (client).

This standard is applicable to all geo-spatial data that are available encoded as GML 2.1.1 which is the current version of the GML standard.

## 2 Conformance

Conformance with this specification shall be checked using all the relevant tests specified in Annex B (normative). The framework, concepts, and methodology for testing, and the criteria to be achieved to claim conformance are specified in ISO 19105: Geographic information — Conformance and Testing.

## 3 Normative references

- [5] Fielding et. al., "Hypertext Transfer Protocol – HTTP/1.1," IETF RFC 2616, June 1999, <http://www.ietf.org/rfc/rfc2616.txt>.

- [6] Bray, Hollander, Layman, eds., “Namespaces In XML”, January 1999, W3CRecommendation, <http://www.w3.org/TR/2000/REC-xml-names>.
- [7] Percivall, George, ed., “The OpenGIS Abstract Specification, Topic 12: OpenGIS Service Architecture”, 2002
- [8] Bradner, Scott, "RFC 2119 Key words for use in RFCs to Indicate Requirement Levels," March 1997, <ftp://ftp.isi.edu/in-notes/rfc2119.txt> .
- [9] ISO/DIS 19111, *Geographic Information – Spatial Referencing by Coordinates*, 2000
- [10] Nicolai, Roel, ed., “The OpenGIS Abstract Specification, Topic 2: Spatial Referencing by Coordinates”, 2002

## 4 Terms and definitions

### 4.1

#### **operation**

specification of a transformation or query that an object may be called to execute [7]

### 4.2

#### **interface**

a named set of operations that characterise the behaviour of an entity [7]

### 4.3

#### **service**

a distinct part of the functionality that is provided by an entity through interfaces [16]

### 4.4

#### **service instance**

an actual implementation of a service; service instance is synonymous with server

### 4.5

#### **client**

a software component that can invoke an operation from a server

### 4.6

#### **request**

an invocation by a client of an operation.



## 4.7

**response**

the result of an operation returned from a server to a client.

## 4.8

**capabilities**

service-level metadata describing the operations and content available at a service instance

## 4.9

**coordinate reference system**

as defined in ISO19111

## 5 Conventions

### 5.1 Normative verbs

In the sections labeled as normative, the key words "**must**", "**must not**", "**required**", "**shall**", "**shall not**", "**should**", "**should not**", "**recommended**", "**may**", and "**optional**" in this document are to be interpreted as described in Internet RFC 2119 [8].

### 5.2 Abbreviated terms

|      |                                    |
|------|------------------------------------|
| API  | Application Program Interface      |
| CGI  | Common Gateway Interface           |
| COTS | Commercial Off The Shelf           |
| CRS  | Coordinate Reference System        |
| CTS  | Coordinate Transformation Services |
| DCP  | Distributed Computing Platform     |
| EPSG | European Petroleum Survey Group    |
| GIS  | Geographic Information System      |
| GML  | Geography Markup Language          |
| HTTP | Hypertext Transfer Protocol        |

|      |  |
|------|--|
| ISO  | International Organization for Standardization |
| KVP  | key-value pair                                 |
| OGC  | Open GIS Consortium                            |
| RFC  | Request for Comments                           |
| URL  | Uniform Resource Locator                       |
| WCTS | Web Coordinate Transformation Service          |
| WMS  | Web Map Service                                |
| WFS  | Web Feature Service                            |
| XML  | eXtended Markup Language                       |

## 6 Basic Service Elements

This section describes aspects of Web Coordinate Transformation Service behaviour that are independent of particular operations or are common to several operations or interfaces.

### 6.1 Version Numbering and Negotiation

#### 6.1.1 Version Number Form

The published specification version number contains three positive integers, separated by decimal points, in the form "x.y.z". The numbers "y" and "z" will never exceed 99.

#### 6.1.2 Version Changes

A particular specification's version number **shall** be changed with each revision. 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 experimental or interim versions. Service instances and their clients need not support all defined versions, but **must** obey the negotiation rules below.

#### 6.1.3 Appearance in Requests and in Service Metadata

The version number appears in at least two places: in the Capabilities XML describing a service, and in the parameter list of client requests to that service. The version number used in a client's request of a particular service instance **must** be equal to a version number which that instance has declared it supports (except during negotiation as

described below). A service instance may support several versions, whose values clients may discover according to the negotiation rules.

#### 6.1.4 Version Number Negotiation

A Client may negotiate with a Service Instance to determine a mutually agreeable specification version. Negotiation is performed using the GetCapabilities operation according to the following rules.

All Capabilities XML must include a protocol version number. In response to a GetCapabilities request containing a version number, an OGC Web Service **must** either respond with output that conforms to that version of the specification, **or** negotiate a mutually agreeable version if the requested version is not implemented on the server. If no version number is specified in the request, the server **must** respond with the highest version it understands and label the response accordingly.

Version number negotiation occurs as follows:

1. If the server implements the requested version number, the server must send that version.
2. If the client request is for an unknown version greater than the lowest version that the server understands, the server must send the highest version less than the requested version.
3. If the client request is for a version lower than any of those known to the server, then the server must send the lowest version it knows.
4. If the client does not understand the new version number sent by the server, it may either cease communicating with the server or send a new request with a new version number that the client does understand but which is less than that sent by the server (if the server had responded with a lower version).
5. If the server had responded with a higher version (because the request was for a version lower than any known to the server), and the client does not understand the proposed higher version, then the client may send a new request with a version number higher than that sent by the server.

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

## 6.2 General HTTP Request Rules

### 6.2.1 Introduction

At present, the only distributed computing platform (DCP) explicitly supported by OGC Web Services is the World Wide Web itself, or more specifically Internet hosts implementing the Hypertext Transfer Protocol (HTTP)[2]. Thus the Online Resource of

each operation supported by a service instance 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 **must** conform to the description in [2] but is otherwise implementation-dependent; only the parameters comprising the service request itself are mandated by the OGC Web Services specifications.

HTTP supports two request methods: GET and POST. One or both of these methods may be defined for a particular OGC Web Service type and offered by a service instance, and the use of the Online Resource URL differs in each case.

### 6.2.2 HTTP Get

An Online Resource URL intended for HTTP GET requests is in fact only a URL prefix to which additional parameters must be appended in order to construct a valid Operation request. A URL prefix is defined as an opaque string including the protocol, hostname, optional port number, path, a question mark '?', and, optionally, one or more server-specific

parameters ending in an ampersand '&'. The prefix uniquely identifies the particular service instance. A client appends the necessary request parameters as name/value pairs in the form "name=value&". The resulting URL must be valid according to the HTTP Common Gateway Interface (CGI) standard [7], which mandates the presence of '?' before the sequence of query parameters and the '&' between each parameter. As with all CGI applications, the query URL is encoded [8] to protect special characters.

The URL prefix must end in either a '?' (in the absence of additional server-specific parameters) or a '&'. In practice, however, Clients **should** be prepared to add a necessary trailing '?' or '&' before appending the Operation parameters defined in this specification in order to construct a valid request URL.

Table 1 summarizes the components of an operation request URL.

**Table 1 A general OGC Web Service Request**

| 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. The prefix is entirely at the discretion of the service provider.                         |
| name=value&                              | One or more standard request parameter name/value pairs defined by an OGC Web Service. The actual list of required and optional parameters is mandated for each operation by the appropriate OWS specification. |

### 6.2.3 HTTP Post

An Online Resource URL intended for HTTP POST requests is a complete and valid URL to which Clients transmit encoded requests in the body of the POST document. A WCTS **must not** require additional parameters to be appended to the URL in order to construct a valid target for the Operation request.

## 6.3 General HTTP Response Rules

Upon receiving a valid request, the service **must** send a response corresponding exactly to the request as detailed in the appropriate specification. Only in the case of Version Negotiation (described above) may the server offer a differing result. Upon receiving an invalid request, the service **must** issue a Service Exception.

**NOTE:** As a practical matter, in the WWW environment a client should be prepared to receive either a valid result, or nothing, or any other result. This is because the client may itself have formed a non-conforming request that inadvertently triggered a reply by something other than an OGC Web Service, because the Service itself may be non conforming, etc.

Response objects **must** be accompanied by the appropriate Multipurpose Internet Mail Extensions (MIME) type [9] for that object.

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.

## 6.4 Request Encoding

This document defines two methods of encoding WCTS requests. The first uses XML as the encoding language. The second method uses keyword-value pairs to encode the various parameters of a request. An example of a keyword value pair is:

```
"REQUEST=GetCapabilities"
```

where "REQUEST" is the keyword and "GETCAPABILITITES" is the value. In both cases, the response to a request or exception reporting must be identical. Table 2 correlates WCTS operations and their encoding semantics as defined in this specification.

**Table 2 Operation Request Encoding**

| Operation              | Request Encoding  |
|------------------------|-------------------|
| GetCapabilities        | XML & KVP         |
| DescribeTransformation | XML & limited KVP |
| IsTransformable        | XML & limited KVP |
| Transform              | XML & limited KVP |

The KVPs may include XML elements. This is for example the case when encoding a Transform request. The geo-spatial data that shall be transformed may be encoded as GML. If so the GML must be URL-encoded to use it within a HTTP-GET request.

## 6.5 Namespaces

Namespaces [3] are used to distinguish the definitions of features and properties defined in application-specific domains from one another, and from the core constructs defined in the GML and WCTS modules. A WCTS must be able to ingest and properly discriminate XML input elements tagged with namespaces and must generate proper XML & GML, correctly tagged with namespaces, so that the output validates against the various schemas mandated by this document..

## 7 Common Elements

### 7.1 Exceptions

Upon receiving an invalid request, the service **must** issue a Service Exception XML message to describe to the client application or its human user the reason(s) that the request is invalid.

Service Exception XML **must** be valid according to the Service Exception Schema definition in Annex A.3. In an HTTP environment, the MIME type of the returned XML **must** be "application/vnd.ogc.se\_xml".

The following Schema fragment shows the structure of an exception:

```
<xs:element name="Exception" type="ExceptionType"/>
<xs:complexType name="ExceptionType">
  <xs:sequence>
    <xs:element name="Message" type="xs:string"/>
    <xs:element name="Location" type="xs:string"/>
  </xs:sequence>
</xs:complexType>
```

### 7.2 XML elements and attributes

There are a number of elements and attributes that are used by several requests and responses. The full XML schema definition of these elements can be found in A.2. These schemas make use of two external schemas, one of them being the GML 2.1.1 geometry schema. The other schema gives definitions for coordinate system, datums et cetera based

on the “Recommended Definition Data for Coordinate References Systems and Coordinate Transformations” [4]. An XML Schema was derived by simply converting the DTD defined by [4] with the help of XML Spy software.

The following elements use definitions of these external schemas and are part of the basic definitions:

```
<xs:element name="SourceCRS" type="CRSType"/>
<xs:element name="DestinationCRS" type="CRSType"/>

<xs:complexType name="CRSType">
  <xs:sequence>
    <xs:element ref="CoordinateReferenceSystem"/>
  </xs:sequence>
</xs:complexType>
<xs:complexType name="DataType">
  <xs:choice>
    <xs:element ref="gml:_Geometry"/>
    <xs:element name="WKTData" type="xs:string"/>
  </xs:choice>
</xs:complexType>
```

As soon as GML 3 is finished the corresponding schemas describing geometry and coordinate systems should replace the two so far used external schemas.

### 7.2.1 Format

The following schema fragment describes the formats that are supported by a WCTS.

```
<xs:complexType name="FormatType">
  <xs:attribute name="name" default="XML">
    <xs:simpleType>
      <xs:restriction base="xs:NMTOKEN">
        <xs:enumeration value="XML"/>
        <xs:enumeration value="WKT"/>
      </xs:restriction>
    </xs:simpleType>
  </xs:attribute>
</xs:complexType>
```

## 8 GetCapabilities Operation (required)

### 8.1 Introduction

The web coordinate transformation service must have the ability to describe its capabilities. This section defines an XML document that a web coordinate transformation server must generate to define its capabilities.

The capabilities document defined in this specification is closely modeled after the capabilities document defined for map servers and web feature servers as described in the Web Map Service Implementation Specification [2] and the Web Feature Service Implementation Specification [3].

## 8.2 Request

### 8.2.1 Key-Value pair encoding

The general form of a **GetCapabilities** request is summarized in Table 1 below.

**Table 3 — The parameters of a GetCapabilities request URL**

| Request Parameter       | Required/<br>Optional | Description     |
|-------------------------|-----------------------|-----------------|
| REQUEST=GetCapabilities | R                     | Request name    |
| VERSION=version         | O                     | Request version |
| SERVICE=WCTS            | R                     | Service type    |

When making this request to a WCTS server, which may offer other OGC Web Services as well, it is necessary to indicate that the client seeks information about the WCTS server in particular. Thus, the SERVICE parameter of the request **must** have the value "WCTS" as shown in Table 3.

### 8.2.2 XML encoding

The **<GetCapabilities>** element is used to request a capabilities document from a web coordinate transformation server.

```

<!-- ===== -->
<!--           element definition           -->
<!-- ===== -->
<!-- root element of a transform request -->
<xs:element name="GetCapabilities" type="wcts:GetCapabilitiesType"/>
<!-- ===== -->
<!--           type definitions           -->
<!-- ===== -->
<xs:complexType name="GetCapabilitiesType">
  <xs:attribute name="version" type="xs:string" use="optional"
    fixed="0.0.3"/>
  <xs:attribute name="service" type="xs:string" use="optional"
    fixed="WCTS"/>
</xs:complexType>

```

The top-level XML element, **GetCapabilities**, has two attributes, **version** and **service**, denoting, respectively, the version number of the protocol and the service it addresses.

## 8.3 Response

### 8.3.1 Response Schema

The schema of the response to a **GetCapabilities** request is normatively defined using XML Schema in Annex A.5.



### 8.3.2 Capabilities Document

The capabilities document is composed of two sections:

#### 1. Service Section

The service section provides information about the service itself.

#### 2. Capabilities Section

The capabilities section specifies the list of requests that the WCTS can handle. Besides the mandatory operations **GetCapabilities**, **IsTransformable** and **Transform** the optional operation **DescribeTransformation** can be described in the **<Request>** section.

Any WCTS has to know at least one coordinate transformation and two coordinate reference systems so that it is able to perform one operation. The known transformations and reference systems are defined in **<KnownTransformation>** and **<KnownCoordinateReferenceSystem>**. Transformations refer to general methods for transformation of coordinates from one reference system into another and not the precise transformations between two particular reference systems. Examples for transformation types are: longitude rotation, abridged Molodenski, geocentric to ellipsoid etc.

### 8.4 Exceptions

In the event that the web coordinate transformation server encounters an error servicing a **GetCapabilities** request, it shall raise an exception as described in Section 7.1 above.

### 8.5 Examples

This example shows what a capabilities document might look like for a basic web coordinate transformation server. To request a capabilities document, a client would issue the following request:

```
<GetCapabilities service="WCTS" version="0.0.3"/>
```

In response to such a request, the web coordinate transformation server might generate a document that looks like:

```
<?xml version="1.0" encoding="iso-8859-1"?>
<WCTS_Capabilities xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:noNamespaceSchemaLocation="http://www.deegree.org/xml/schemas/wcts/capabilities.xsd" version="0.0.3" updateSequence="1">
  <Service>
    <Name>WCTS</Name>
    <Title>Web Coordinate Transformation Service</Title>
    <Abstract>Service for transforming coordinates from one CRS to another
      through a network</Abstract>
    <KeywordList>
      <Keyword>Coordinate Reference System</Keyword>
      <Keyword>transformation</Keyword>
    </KeywordList>
  </Service>
</WCTS_Capabilities>
```

```

<OnlineResource xmlns:xlink="http://www.w3c.org/1999/xlink"
  xlink:type="simple" xlink:href="http://www.lat-lon.de"/>
<ContactInformation>
  <ContactPersonPrimary>
    <ContactPerson>Andreas Poth</ContactPerson>
    <ContactOrganization>lat/lon</ContactOrganization>
  </ContactPersonPrimary>
  <ContactPosition>Geschäftsführer</ContactPosition>
  <ContactAddress>
    <AddressType>postal</AddressType>
    <Address>Meckenheimer Allee 176</Address>
    <City>Bonn</City>
    <StateOrProvince>NRW</StateOrProvince>
    <PostCode>53115</PostCode>
    <Country>Germany</Country>
  </ContactAddress>
  <ContactVoiceTelephone>++49 228 732838</ContactVoiceTelephone>
  <ContactFacsimileTelephone>++49 228 732153</ContactFacsimileTelephone>
  <ContactElectronicMailAddress>poth@lat-lon.de
    </ContactElectronicMailAddress>
  </ContactInformation>
  <Fees>none</Fees>
  <AccessConstraints>none</AccessConstraints>
</Service>
<Capability userDefinedCoordinateSystems="false"
userDefinedTransformations="false">
  <Request>
    <GetCapabilities>
      <Format>String</Format>
      <DCPType>
        <HTTP>
          <Get>
            <OnlineResource xmlns:xlink="http://www.w3c.org/1999/xlink"
              xlink:type="simple"
              xlink:href="http://www.lat-lon.de/transform?"/>
          </Get>
          <Post>
            <OnlineResource xmlns:xlink="http://www.w3c.org/1999/xlink"
              xlink:type="simple"
              xlink:href="http://www.lat-lon.de/transform"/>
          </Post>
        </HTTP>
      </DCPType>
    </GetCapabilities>
    <Transform>
      <Format>String</Format>
      <DCPType>
        <HTTP>
          <Post>
            <OnlineResource xmlns:xlink="http://www.w3c.org/1999/xlink"
              xlink:type="simple"
              xlink:href="http://www.lat-lon.de/transform"/>
          </Post>
        </HTTP>
      </DCPType>
    </Transform>
    <IsTransformable>
      <Format>String</Format>
      <DCPType>
        <HTTP>
          <Post>
            <OnlineResource xmlns:xlink="http://www.w3c.org/1999/xlink"
              xlink:type="simple"

```

```

        xlink:href="http://www.lat-lon.de/transform"/>
      </Post>
    </HTTP>
  </DCPType>
</IsTransformable>
<DescribeTransformation>
  <Format>String</Format>
  <DCPType>
    <HTTP>
      <Post>
        <OnlineResource xmlns:xlink="http://www.w3c.org/1999/xlink"
          xlink:type="simple"
          xlink:href="http://www.lat-lon.de/transform"/>
      </Post>
    </HTTP>
  </DCPType>
</DescribeTransformation>
</Request>
<!-- ===== -->
<!-- list of transformation types known by the WCTS -->
<!-- ===== -->
<KnownTransformation>
  <Authority>EPSG</Authority>
  <Code>9601</Code>
</KnownTransformation>
<KnownTransformation>
  <Authority>EPSG</Authority>
  <Code>9602</Code>
</KnownTransformation>
<KnownTransformation>
  <Authority>EPSG</Authority>
  <Code>9603</Code>
</KnownTransformation>
<KnownTransformation>
  <Authority>EPSG</Authority>
  <Code>9604</Code>
</KnownTransformation>
<KnownTransformation>
  <Authority>EPSG</Authority>
  <Code>9807</Code>
</KnownTransformation>
<!-- ===== -->
<!-- list of coordinate reference systems known by the WCTS -->
<!-- ===== -->
<KnownCoordinateReferenceSystem>
  <Authority>EPSG</Authority>
  <Code>4326</Code>
</KnownCoordinateReferenceSystem>
<KnownCoordinateReferenceSystem>
  <Authority>EPSG</Authority>
  <Code>23031</Code>
</KnownCoordinateReferenceSystem>
<KnownCoordinateReferenceSystem>
  <Authority>EPSG</Authority>
  <Code>23032</Code>
</KnownCoordinateReferenceSystem>
<KnownCoordinateReferenceSystem>
  <Authority>EPSG</Authority>
  <Code>31467</Code>
</KnownCoordinateReferenceSystem>
</Capability>
</WCTS_Capabilities>

```

## 9 IsTransformable Operation

### 9.1 Introduction

The **IsTransformable** request allows clients of the WCTS to check if a transformation between two coordinate reference systems is possible. It only will be checked if there is a valid way (sequence of transformation steps) to transform the coordinates of one CRS to those of another one. It will not be checked if this transformation makes any sense nor if it is possible to be performed for each specific coordinate expression that may be submitted by a Transform request.

In principle this information could be extracted from the capabilities of the WCTS as the elements **<KnownTransformation>** and **<KnownCoordinateReferenceSystem>** provide the necessary information. The analysis of these elements in regard to the possibility of a transformation between two reference systems is in some cases rather complicated and would need powerful client logic. It seems to make more sense to provide this information directly via a distinct operation, allowing simple clients to use the service.

### 9.2 Request

#### 9.2.1 Key-Value pair encoding

Table 4 — The parameters of an IsTransformable request URL

| Request Parameter       | Required/<br>Optional | Description   |
|-------------------------|-----------------------|---|
| REQUEST=IsTransformable | R                     | Request name  |
| VERSION=version         | O                     | Request version   |
| SOURCECRS               | R                     | unique Identifier of the source spatial reference system      |
| DESTINATIONCRS          | R                     | unique Identifier of the destination spatial reference system |

#### 9.2.2 XML encoding

```
<!-- ===== -->
<!--           element definition           -->
<!-- ===== -->
<xs:element name="Transformable" type="TransformableType"/>
<!-- ===== -->
<!--           type definitions           -->
<!-- ===== -->
<xs:complexType name="TransformableType">
  <xs:sequence>
    <xs:element ref="SourceCRS"/>
```

```

    <xs:element ref="DestinationCRS"/>
  </xs:sequence>
  <xs:attribute name="version" fixed="0.0.3" type="xs:string"/>
</xs:complexType>

```

### 9.3 Response

The response to an **IsTransformable** request is a simple ‘true’ or ‘false’ depending on whether the WCTS can perform the requested transformation.

```

<xs:element name="TransformableResponse" type="TransformableResponseType"/>
<!-- response type -->
<xs:complexType name="TransformableResponseType">
  <xs:attribute name="transformable" use="required" type="xs:boolean"/>
</xs:complexType>

```

### 9.4 Exceptions

In the event that the web coordinate transformation server encounters an error servicing a **IsTransformable** request, it shall raise an exception as described in Section 7.1 above.

### 9.5 Examples

#### 9.5.1 IsTransformable Request

An IsTransformable request for evaluating if a transformation between EPSG:4326 and EPSG:23032 is possible will look like this:

```

<?xml version="1.0" encoding="UTF-8"?>
<Transformable xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:noNamespaceSchemaLocation=
"http://www.deegree.org/xml/schemas/wcts/transformableRequest.xsd">
  <SourceCRS>
    <CoordinateReferenceSystem>
      <Identifier>
        <code>4326</code>
        <codeSpace>EPSG</codeSpace>
      </Identifier>
    </CoordinateReferenceSystem>
  </SourceCRS>
  <DestinationCRS>
    <CoordinateReferenceSystem>
      <Identifier>
        <code>23032</code>
        <codeSpace>EPSG</codeSpace>
      </Identifier>
    </CoordinateReferenceSystem>
  </DestinationCRS>
</Transformable>

```

#### 9.5.2 IsTransformable Response

The servers response for the case that the transformation is possible looks like this:

```

<?xml version="1.0" encoding="UTF-8"?>

```

```
<TransformableResponse xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:noNamespaceSchemaLocation=
"http://www.deegree.org/xml/schemas/wcts/transformableResponse.xsd"
transformable="true"/>
```

## 10 Transform Operation (required)

### 10.1 Introduction

The **Transform** operation is central to the web coordinate transformation server. It allows the transformation of coordinates from one coordinate reference system into another. Coordinates can either be provided as GML or WKT with support of GML being mandatory. Optionally the WCTS can support user-defined transformations which make it necessary for the client to provide the parameters for the transformation sequence.

The transformation of a geometry into another is done by transforming the individual coordinates. This means that geometries using splines and other non-linear interpolations that will be available in future with GML3 are not explicitly transformed.

### 10.2 Request

#### 10.2.1 Key-Value pair encoding

**Table 5 — The parameters of a Transform request URL**

| Request Parameter      | Required/<br>Optional | Description   |
|------------------------|-----------------------|---|
| REQUEST=Transform      | R                     | Request name  |
| VERSION=version        | O                     | Request version   |
| INPUTFORMAT            | O                     | Format of the input data that has to be transformed. If this parameter is missing GML is assumed. |
| OUTPUTFORMAT           | O                     | Format of the output data that has to be delivered. If this parameter is missing GML is assumed.  |
| SOURCECRS              | R                     | unique Identifier of the source spatial reference system  |
| DESTINATIONCRS         | R                     | unique Identifier of the destination spatial reference system                                     |
| TRANSFORMATIONSEQUENCE | O                     | Sequence of transformation steps. Each step has to be described in XML                            |
| DATA                   | R                     | The data that has to be transformed in GML or WKT format  |

Using a Key-Value pair encoding of a **Transform** request the number of the geometries submitted with one request is limited to one.

### 10.2.2 XML encoding

The following schema fragment shows the structure of an XML encoded **Transform** request:

```
<!-- ===== -->
<!--           element definitions           -->
<!-- ===== -->
<!-- root element of a transform request -->
<xs:element name="Transform" type="TransformType"/>
<!-- sub elements -->
<xs:element name="InputFormat" type="FormatType"/>
<xs:element name="OutputFormat" type="FormatType"/>
<xs:element name="TransformationSequence" type="TransformationSequenceType"/>
<xs:element name="Data" type="DataType"/>
<!-- ===== -->
<!--           type definitions           -->
<!-- ===== -->
<xs:complexType name="TransformType">
  <xs:sequence>
    <xs:element ref="InputFormat" minOccurs="0"/>
    <xs:element ref="OutputFormat" minOccurs="0"/>
    <xs:element ref="SourceCRS"/>
    <xs:element ref="DestinationCRS"/>
    <xs:element ref="TransformationSequence" minOccurs="0"/>
    <xs:element ref="Data" maxOccurs="unbounded"/>
  </xs:sequence>
  <xs:attribute name="version" use="required" fixed="0.0.3"
    type="xs:string"/>
</xs:complexType>
<!-- sequence of coordinate system transformations that may be defined by the
      calling client to performed a specific transformation -->
<xs:complexType name="TransformationSequenceType">
  <xs:sequence>
    <xs:element ref="ParameterizedTransformation" maxOccurs="unbounded"/>
  </xs:sequence>
</xs:complexType>
```

### 10.3 Response

The response to a **Transform** request is a geometry in either GML or WKT format.

```
<xs:element name="TransformResponse" type="TransformResponseType"/>
<xs:element name="Data" type="DataType"/>
<xs:complexType name="TransformResponseType">
  <xs:sequence>
    <xs:element ref="Data" minOccurs="1" maxOccurs="unbounded"/>
  </xs:sequence>
</xs:complexType>
```

## 10.4 Exceptions

In the event that the web coordinate transformation server encounters an error servicing a **Transform** request, it shall raise an exception as described in Section 7.1 above.

## 10.5 Examples

### 10.5.1 Transform request

If a client wants to transform a LineString from EPSG:2303 to EPSG:31467 using the default transformation steps it has to construct the following request:

```
<?xml version="1.0" encoding="UTF-8"?>
<Transform xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns:gml="http://www.opengis.net/gml" xsi:noNamespaceSchemaLocation=
"http://www.deegree.org/xml/schemas/wcts/transformationRequest.xsd"
version="0.0.3">
  <SourceCRS>
    <CoordinateReferenceSystem>
      <Identifier>
        <code>23032</code>
        <codeSpace>EPSG</codeSpace>
      </Identifier>
    </CoordinateReferenceSystem>
  </SourceCRS>
  <DestinationCRS>
    <CoordinateReferenceSystem>
      <Identifier>
        <code>31467</code>
        <codeSpace>EPSG</codeSpace>
      </Identifier>
    </CoordinateReferenceSystem>
  </DestinationCRS>
  <Data>
    <gml:LineString srsName="http://www.opengis.net/gml/srs/epsg.xml#23032">
      <gml:coordinates>32691885.01,6099040.61 32752621.23,6157840.13
        32803597.37,6328648.53</gml:coordinates>
    </gml:LineString>
  </Data>
</Transform>
```

### 10.5.2 Transform response

As response to a request for transforming a LineString from EPSG:2303 to EPSG:31467 the server will response – if no exception occurs – with:

```
<?xml version="1.0" encoding="UTF-8"?>
<TransformResponse xmlns:gml="http://www.opengis.net/gml"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:noNamespaceSchemaLocation="http://www.deegree.org/xml/schemas/wcts/transfor
mationResponse.xsd">
  <Data>
    <gml:LineString srsName="http://www.opengis.net/gml/srs/epsg.xml#31467">
      <gml:coordinates>2883605.38,6113004.65 2941851.73,6174476.40
        2985404.92,6347687.71 </gml:coordinates>
    </gml:LineString>
```



```
</Data>
</TransformResponse>
```

## 11 DescribeTransformation Operation (optional)

### 11.1 Introduction

Support of the **DescribeTransformation** request is optional for a web coordinate transformation server. It offers the description of a transformation from one coordinate reference system into another. The WCTS DescribeTransformation request supplies the steps which are necessary for the transformation. The response can either be encoded as XML or WKT.

### 11.2 Request

#### 11.2.1 Key-Value pair encoding

**Table 6 — The parameters of a DescribeTransformation request URL**

| Request Parameter              | Required/<br>Optional | Description   |
|--------------------------------|-----------------------|---|
| REQUEST=DescribeTransformation | R                     | Request name  |
| VERSION=version                | O                     | Request version   |
| SOURCECRS                      | R                     | unique Identifier of the source spatial reference system                  |
| DESTINATIONCRS                 | R                     | unique Identifier of the destination spatial reference system             |
| FORMAT                         | O                     | Format that the response object will be encoded in. Default value is XML. |

#### 11.2.2 XML encoding

```
<!-- ===== -->
<!--           element definitions           -->
<!-- ===== -->
<!-- root element of a transform request -->
<xs:element name="DescribeTransformation" type="DescribeTransformationType"/>
<!-- sub elements -->
<xs:element name="Format" type="FormatType"/>
<!-- ===== -->
<!--           type definitions           -->
<!-- ===== -->
<xs:complexType name="DescribeTransformationType">
  <xs:sequence>
    <xs:element ref="Format"/>
    <xs:element ref="SourceCRS"/>
    <xs:element ref="DestinationCRS"/>
  </xs:sequence>
  <xs:attribute name="version" fixed="0.0.3" type="xs:string"/>
</xs:complexType>
```

### 11.3 Response

As the transformation from one coordinate reference system to another cannot usually be done by a simple transformation, the transformation is described by its transformation steps. One transformation step corresponds to a **ParameterizedTransformation** element as defined in [4]. The number of transformation steps is provided by the **numberOfTransformations** attribute.

It is possible that a transformation is not feasible. Possible reasons for this are that the web coordinate transformation service does not know the necessary transformation steps or that a transformation is not possible at all (for example the transformation of a 3D to a 2D system). If a transformation is not feasible for a service WCTS returns an Exception.

A schema fragment describing the response to a **DescribeTransformation** request follows:

```
<!-- ===== -->
<!--           element definitions           -->
<!-- ===== -->
<!-- root element of a transform request -->
<xs:element name="DescribeTransformationResponse"
            type="DescribeTransformationResponseType"/>
<!-- ===== -->
<!--           type definitions           -->
<!-- ===== -->
<!-- response type -->
<xs:complexType name="DescribeTransformationResponseType">
  <xs:sequence >
    <xs:element ref="ParameterizedTransformation" minOccurs="1"
                maxOccurs="unbounded"/>
  </xs:sequence >
  <xs:attribute name="numberOfTransformations" use="required"
                type="xs:positiveInteger"/>
</xs:complexType>
```

### 11.4 Exceptions

In the event that the web coordinate transformation server encounters an error servicing a **DescribeTransformation** request, it shall raise an exception as described in Section 7.1 above.

### 11.5 Examples

#### 11.5.1 DescribeTransformation request

A request for the description of a transformation has to be encoded like this:

```
<?xml version="1.0" encoding="UTF-8"?>
<DescribeTransformation xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:noNamespaceSchemaLocation=
```

```
"http://www.deegree.org/xml/schemas/wcts/DescribeTransformationRequest.xsd">
  <Format>XML</Format>
  <SourceCRS>
    <CoordinateReferenceSystem>
      <Identifier>
        <code>4326</code>
        <codeSpace>EPSG</codeSpace>
      </Identifier>
    </CoordinateReferenceSystem>
  </SourceCRS>
  <DestinationCRS>
    <CoordinateReferenceSystem>
      <Identifier>
        <code>31467</code>
        <codeSpace>EPSG</codeSpace>
      </Identifier>
    </CoordinateReferenceSystem>
  </DestinationCRS>
</DescribeTransformation>
```

### 11.5.2 DescribeTransformation response

If no exception occurs the server will reply to a DescribeTransformation request with a list of transformations. To transform EPSG:4326 to EPSG:31467 just one transformation step is required.

```
<?xml version="1.0" encoding="UTF-8"?>
<DescribeTransformationResponse
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xsi:noNamespaceSchemaLocation=
    "http://www.deegree.org/xml/schemas/wcts/DescribeTransformationResponse.xsd"
  numberOfTransformations="1">
  <ParameterizedTransformation>
    <TransformationMethod>
      <Identifier>
        <code>9807</code>
        <codeSpace>EPSG</codeSpace>
      </Identifier>
    </TransformationMethod>
  </ParameterizedTransformation>
</DescribeTransformationResponse>
```

## Annex A (normative)

### XML Schema definitions

#### A.1 Introduction

#### A.2 Basic Definitions

```
<?xml version="1.0" encoding="UTF-8"?>
<xs:schema xmlns:gml="http://www.opengis.net/gml" xmlns:xs="http://www.w3.org/2001/XMLSchema"
  elementFormDefault="qualified" attributeFormDefault="unqualified">
  <!--
    authors:
    Andreas Poth / Markus Müller
    lat/lon
    Meckenheimer Allee 176
    53115 Bonn
    Germany

    Version: 9.8.2002
  -->
  <xs:import schemaLocation="http://www.deegree.org/xml/schemas/wcts/crs_ogc_01_014.xsd"/>
  <xs:import schemaLocation="http://www.deegree.org/xml/schemas/wcts/geometry.xsd"/>
  <!-- ===== -->
  <!-- element definitions -->
  <!-- ===== -->
  <xs:element name="SourceCRS" type="CRSType"/>
  <xs:element name="DestinationCRS" type="CRSType"/>
  <!-- ===== -->
  <!-- type definitions -->
  <!-- ===== -->
  <!-- defines the type for input and output format of a transform request. -->
  <xs:complexType name="FormatType">
    <xs:attribute name="name" default="XML">
      <xs:simpleType>
        <xs:restriction base="xs:NMTOKEN">
          <xs:enumeration value="XML"/>
          <xs:enumeration value="WKT"/>
        </xs:restriction>
      </xs:simpleType>
    </xs:attribute>
  </xs:complexType>
  <!-- coordinate reference system of the data to be transformed -->
  <xs:complexType name="CRSType">
    <xs:sequence>
      <xs:element ref="CoordinateReferenceSystem"/>
    </xs:sequence>
  </xs:complexType>
  <!-- data to be transformed or has been transformed -->
  <xs:complexType name="DataType">
    <xs:choice>
      <xs:element ref="gml:_Geometry"/>
      <xs:element name="WKTDData" type="xs:string"/>
    </xs:choice>
  </xs:complexType>
</xs:schema>
```

```
</xs:choice>  
</xs:complexType>  
</xs:schema>
```

### A.3 Exception (Response)

```

<?xml version="1.0" encoding="UTF-8"?>
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema" elementFormDefault="qualified"
attributeFormDefault="unqualified">

  <!--
  authors:
  Andreas Poth / Markus Müller
  lat/ion
  Meckenheimer Allee 176
  53115 Bonn
  Germany

  Version: 9.8.2002
  -->

  <!-- ===== -->
  <!--           element definitions           -->
  <!-- ===== -->
  <xs:element name="Exception" type="ExceptionType"/>
  <!-- ===== -->
  <!--           type definitions           -->
  <!-- ===== -->
  <xs:complexType name="ExceptionType">
    <xs:sequence>
      <xs:element name="Message" type="xs:string"/>
      <xs:element name="Location" type="xs:string"/>
    </xs:sequence>
  </xs:complexType>
</xs:schema>

```

## A.4 GetCapabilities Request

```

<?xml version="1.0" encoding="UTF-8"?>
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema" elementFormDefault="qualified"
attributeFormDefault="unqualified">

  <!--
  authors:
  Andreas Poth / Markus Müller
  lat/lon
  Meckenheimer Allee 176
  53115 Bonn
  Germany

  Version: 9.8.2002
  -->

  <!-- ===== -->
  <!--           element definition           -->
  <!-- ===== -->
  <!-- root element of a transform request -->
  <xs:element name="GetCapabilities" type="wcts:GetCapabilitiesType"/>
  <!-- ===== -->
  <!--           type definitions           -->
  <!-- ===== -->
  <xs:complexType name="GetCapabilitiesType">
    <xs:attribute name="version" type="xs:string" use="optional" fixed="0.0.3"/>
    <xs:attribute name="service" type="xs:string" use="optional" fixed="WCTS"/>
  </xs:complexType>
</xs:schema>

```

## A.5 Capabilities (Response to GetCapabilities request)

```
<?xml version="1.0" encoding="UTF-8"?>
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema" elementFormDefault="qualified"
attributeFormDefault="unqualified">

  <!--
  authors:
  Andreas Poth / Markus Müller
  lat/lon
  Meckenheimer Allee 176
  53115 Bonn
  Germany

  Version: 9.8.2002
  -->

  <!-- ===== -->
  <!--           element definitions           -->
  <!-- ===== -->
  <!-- root element of a transform request -->
  <xs:element name="WCTS_Capabilities" type="WCTS_CapabilitiesType"/>
  <!-- sub elements -->
  <xs:element name="Service" type="ServiceType"/>
  <xs:element name="Capability" type="CapabilityType"/>
  <xs:element name="Name" type="xs:string"/>
  <xs:element name="Title" type="xs:string"/>
  <xs:element name="Abstract" type="xs:string"/>
  <xs:element name="OnlineResource" type="OnlineResourceType"/>
  <xs:element name="Format" type="xs:string"/>
  <xs:element name="DCPType" type="DCPTypeType"/>
  <xs:element name="HTTP" type="HTTPType"/>
  <xs:element name="KeywordList" type="KeywordListType"/>
  <xs:element name="Keyword" type="xs:string"/>
  <xs:element name="ContactInformation" type="ContactInformationType"/>
  <xs:element name="ContactPersonPrimary" type="ContactPersonPrimaryType"/>
  <xs:element name="ContactPerson" type="xs:string"/>
  <xs:element name="ContactOrganization" type="xs:string"/>
  <xs:element name="ContactPosition" type="xs:string"/>
  <xs:element name="ContactAddress" type="ContactAddressType"/>
  <xs:element name="AddressType" type="xs:string"/>
  <xs:element name="Address" type="xs:string"/>
  <xs:element name="City" type="xs:string"/>
  <xs:element name="StateOrProvince" type="xs:string"/>
  <xs:element name="PostCode" type="xs:string"/>
  <xs:element name="Country" type="xs:string"/>
  <xs:element name="ContactVoiceTelephone" type="xs:string"/>
  <xs:element name="ContactFacsimileTelephone" type="xs:string"/>
  <xs:element name="ContactElectronicMailAddress" type="xs:string"/>
  <xs:element name="Fees" type="xs:string"/>
  <xs:element name="AccessConstraints" type="xs:string"/>
  <xs:element name="Request" type="RequestType"/>
  <xs:element name="KnownTransformation" type="KnownTransformationType"/>
  <xs:element name="KnownCoordinateReferenceSystem"
type="KnownCoordinateReferenceSystemType"/>
  <!-- ===== -->
  <!--           type definitions           -->
  <!-- ===== -->
  <xs:complexType name="WCTS_CapabilitiesType">
```



```

<xs:sequence>
  <xs:element ref="Service"/>
  <xs:element ref="Capability"/>
</xs:sequence>
<xs:attribute name="version" type="xs:string"/>
<xs:attribute name="updateSequence" type="xs:string"/>
</xs:complexType>
<!-- ===== OnlineResourceType ===== -->
<xs:complexType name="OnlineResourceType">
  <xs:attribute name="xmlns:xlink" fixed="http://www.w3.org/1999/xlink" type="xs:string"/>
  <xs:attribute name="xlink:type" fixed="simple" type="xs:string"/>
  <xs:attribute name="xlink:href" type="xs:string"/>
</xs:complexType>
<!-- ===== Service Type ===== -->
<xs:complexType name="ServiceType">
  <xs:sequence>
    <xs:element ref="Name"/>
    <xs:element ref="Title"/>
    <xs:element ref="Abstract" minOccurs="0" maxOccurs="1"/>
    <xs:element ref="KeywordList" minOccurs="0" maxOccurs="1"/>
    <xs:element ref="OnlineResource"/>
    <xs:element ref="ContactInformation"/>
    <xs:element ref="Fees" minOccurs="0" maxOccurs="1"/>
    <xs:element ref="AccessConstraints" minOccurs="0" maxOccurs="1"/>
  </xs:sequence>
</xs:complexType>
<!-- ===== KeywordListType ===== -->
<xs:complexType name="KeywordListType">
  <xs:sequence>
    <xs:element ref="Keyword" minOccurs="0" maxOccurs="unbounded"/>
  </xs:sequence>
</xs:complexType>
<!-- ===== ContactInformationType ===== -->
<xs:complexType name="ContactInformationType">
  <xs:sequence>
    <xs:element ref="ContactPersonPrimary" minOccurs="0" maxOccurs="1"/>
    <xs:element ref="ContactPosition" minOccurs="0" maxOccurs="1"/>
    <xs:element ref="ContactAddress" minOccurs="0" maxOccurs="1"/>
    <xs:element ref="ContactVoiceTelephone" minOccurs="0" maxOccurs="1"/>
    <xs:element ref="ContactFacsimileTelephone" minOccurs="0" maxOccurs="1"/>
    <xs:element ref="ContactElectronicMailAddress" minOccurs="0" maxOccurs="1"/>
  </xs:sequence>
</xs:complexType>
<!-- ===== ContactPersonPrimaryType ===== -->
<xs:complexType name="ContactPersonPrimaryType">
  <xs:sequence>
    <xs:element ref="ContactPerson"/>
    <xs:element ref="ContactOrganization"/>
  </xs:sequence>
</xs:complexType>
<!-- ===== ContactAddressType ===== -->
<xs:complexType name="ContactAddressType">
  <xs:sequence>
    <xs:element ref="AddressType"/>
    <xs:element ref="Address"/>
    <xs:element ref="City"/>
    <xs:element ref="StateOrProvince"/>
    <xs:element ref="PostCode"/>
    <xs:element ref="Country"/>
  </xs:sequence>
</xs:complexType>
<!-- ===== Capability Type ===== -->

```

```

<xs:complexType name="CapabilityType">
  <xs:sequence>
    <xs:element ref="Request"/>
    <xs:element ref="KnownTransformation" minOccurs="1" maxOccurs="unbounded"/>
    <xs:element ref="KnownCoordinateReferenceSystem" minOccurs="2"
maxOccurs="unbounded"/>
    <xs:element name="VendorSpecificCapabilities" type="xs:string" minOccurs="0"
maxOccurs="unbounded"/>
  </xs:sequence>
  <xs:attribute name="userDefinedCoordinateSystems" default="false" type="xs:boolean"/>
  <xs:attribute name="userDefinedTransformations" default="false" type="xs:boolean"/>
</xs:complexType>
<!-- ===== RequestType ===== -->
<xs:complexType name="RequestType">
  <xs:sequence>
    <xs:element name="GetCapabilities" type="ActionType"/>
    <xs:element name="Transform" type="ActionType"/>
    <xs:element name="IsTransformable" type="ActionType"/>
    <xs:element name="DescribeTransformation" type="ActionType" minOccurs="0"
maxOccurs="1"/>
  </xs:sequence>
</xs:complexType>
<!-- ===== ActionType ===== -->
<xs:complexType name="ActionType">
  <xs:sequence>
    <xs:element ref="Format" minOccurs="1" maxOccurs="unbounded"/>
    <xs:element ref="DCPType" minOccurs="1" maxOccurs="unbounded"/>
  </xs:sequence>
</xs:complexType>
<!-- ===== DCPTType ===== -->
<xs:complexType name="DCPTType">
  <xs:choice>
    <xs:element ref="HTTP"/>
  </xs:choice>
</xs:complexType>
<!-- ===== HTTPType ===== -->
<xs:complexType name="HTTPType">
  <xs:choice maxOccurs="unbounded">
    <xs:element name="Post" type="AccessMethodType"/>
    <xs:element name="Get" type="AccessMethodType"/>
  </xs:choice>
</xs:complexType>
<!-- ===== AccessMethodType ===== -->
<xs:complexType name="AccessMethodType">
  <xs:sequence>
    <xs:element ref="OnlineResource"/>
  </xs:sequence>
</xs:complexType>
<!-- ===== KnownTransformationType ===== -->
<xs:complexType name="KnownTransformationType">
  <xs:sequence>
    <xs:element name="Authority" type="xs:string"/>
    <xs:element name="Code" type="xs:string"/>
  </xs:sequence>
</xs:complexType>
<!-- ===== KnownCoordinateReferenceSystemType ===== -->
<xs:complexType name="KnownCoordinateReferenceSystemType">
  <xs:sequence>
    <xs:element name="Authority" type="xs:string"/>
    <xs:element name="Code" type="xs:string"/>
  </xs:sequence>
</xs:complexType>

```

</xs:schema>

## A.6 IsTransformable Request

```

<?xml version="1.0" encoding="UTF-8"?>
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema" elementFormDefault="qualified"
attributeFormDefault="unqualified">
  <xs:import schemaLocation="http://www.deegree.org/xml/schemas/wcts/basic.xsd"/>

  <!--
  authors:
  Andreas Poth / Markus Müller
  lat/ion
  Meckenheimer Allee 176
  53115 Bonn
  Germany

  Version: 9.8.2002
  -->

  <!-- ===== -->
  <!--           element definitions           -->
  <!-- ===== -->
  <!-- root element of a transform request -->
  <xs:element name="Transformable" type="TransformableType"/>
  <!-- ===== -->
  <!--           type definitions           -->
  <!-- ===== -->
  <xs:complexType name="TransformableType">
    <xs:sequence>
      <xs:element ref="SourceCRS"/>
      <xs:element ref="DestinationCRS"/>
    </xs:sequence>
    <xs:attribute name="version" type="xs:string" fixed="0.0.3"/>
  </xs:complexType>
</xs:schema>

```

## A.7 IsTransformable Response

```
<?xml version="1.0" encoding="UTF-8"?>
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema" elementFormDefault="qualified"
attributeFormDefault="unqualified">

  <!--
  authors:
  Andreas Poth / Markus Müller
  lat/ion
  Meckenheimer Allee 176
  53115 Bonn
  Germany

  Version: 9.8.2002
  -->

  <!-- ===== -->
  <!--           element definitions           -->
  <!-- ===== -->
  <!-- root element of a transformable response -->
  <xs:element name="TransformableResponse" type="TransformableResponseType"/>
  <!-- ===== -->
  <!--           type definitions           -->
  <!-- ===== -->
  <!-- response type -->
  <xs:complexType name="TransformableResponseType">
    <xs:attribute name="transformable" type="xs:boolean" use="required"/>
  </xs:complexType>
</xs:schema>
```

## A.8 Transform Request

```

<?xml version="1.0" encoding="UTF-8"?>
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema" elementFormDefault="qualified">

  <!--
  authors:
  Andreas Poth / Markus Müller
  lat/lon
  Meckenheimer Allee 176
  53115 Bonn
  Germany

  Version: 9.8.2002
  -->

  <xs:import schemaLocation="http://www.deegree.org/xml/schemas/wcts/crs_ogc_01_014.xsd"/>
  <xs:import schemaLocation="http://www.deegree.org/xml/schemas/wcts/basic.xsd"/>
  <!-- ===== -->
  <!--                      element definitions                      -->
  <!-- ===== -->
  <!-- root element of a transform request -->
  <xs:element name="Transform" type="TransformType"/>
  <!-- sub elements -->
  <xs:element name="InputFormat" type="FormatType"/>
  <xs:element name="OutputFormat" type="FormatType"/>
  <xs:element name="TransformationSequence" type="TransformationSequenceType"/>
  <xs:element name="Data" type="DataType"/>
  <!-- ===== -->
  <!--                      type definitions                      -->
  <!-- ===== -->
  <xs:complexType name="TransformType">
    <xs:sequence>
      <xs:element ref="InputFormat" minOccurs="0"/>
      <xs:element ref="OutputFormat" minOccurs="0"/>
      <xs:element ref="SourceCRS"/>
      <xs:element ref="DestinationCRS"/>
      <xs:element ref="TransformationSequence" minOccurs="0"/>
      <xs:element ref="Data" maxOccurs="unbounded"/>
    </xs:sequence>
    <xs:attribute name="version" type="xs:string" use="required" fixed="0.0.3"/>
  </xs:complexType>
  <!-- sequence of coordinate system transformations that may be defined by the
  calling client to performed a specific transformation -->
  <xs:complexType name="TransformationSequenceType">
    <xs:sequence>
      <xs:element ref="ParameterizedTransformation" maxOccurs="unbounded"/>
    </xs:sequence>
  </xs:complexType>
</xs:schema>

```

## A.9 Transform Response

```

<?xml version="1.0" encoding="UTF-8"?>
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema" xmlns:gml="http://www.opengis.net/gml"
  elementFormDefault="qualified" attributeFormDefault="unqualified">

  <!--
  authors:
  Andreas Poth / Markus Müller
  lat/lon
  Meckenheimer Allee 176
  53115 Bonn
  Germany

  Version: 9.8.2002
  -->

  <xs:import schemaLocation="http://www.deegree.org/xml/schemas/wcts/basic.xsd"/>
  <!-- ===== -->
  <!-- element definitions -->
  <!-- ===== -->
  <!-- root element of a transform response -->
  <xs:element name="TransformResponse" type="TransformResponseType"/>
  <!-- sub elements -->
  <xs:element name="Data" type="DataType"/>
  <!-- ===== -->
  <!-- type definitions -->
  <!-- ===== -->
  <xs:complexType name="TransformResponseType">
    <xs:sequence>
      <xs:element ref="Data" maxOccurs="unbounded"/>
    </xs:sequence>
  </xs:complexType>
</xs:schema>

```

## A.10 Describe Transformation Request

```

<?xml version="1.0" encoding="UTF-8"?>
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema" elementFormDefault="qualified"
attributeFormDefault="unqualified">
  <xs:import schemaLocation="http://www.deegree.org/xml/schemas/wcts/basic.xsd"/>

  <!--
  authors:
  Andreas Poth / Markus Müller
  lat/ion
  Meckenheimer Allee 176
  53115 Bonn
  Germany

  Version: 9.8.2002
  -->

  <!-- ===== -->
  <!--           element definitions           -->
  <!-- ===== -->
  <!-- root element of a transform request -->
  <xs:element name="DescribeTransformation" type="DescribeTransformationType"/>
  <!-- sub elements -->
  <xs:element name="Format" type="FormatType"/>
  <!-- ===== -->
  <!--           type definitions           -->
  <!-- ===== -->
  <xs:complexType name="DescribeTransformationType">
    <xs:sequence>
      <xs:element ref="Format"/>
      <xs:element ref="SourceCRS"/>
      <xs:element ref="DestinationCRS"/>
    </xs:sequence>
    <xs:attribute name="version" type="xs:string" fixed="0.0.3"/>
  </xs:complexType>
</xs:schema>

```



## A.11 DescribeTransformation Response

```

<?xml version="1.0" encoding="UTF-8"?>
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema" elementFormDefault="qualified"
attributeFormDefault="unqualified">

  <!--
  authors:
  Andreas Poth / Markus Müller
  lat/lon
  Meckenheimer Allee 176
  53115 Bonn
  Germany

  Version: 9.8.2002
  -->

  <xs:import schemaLocation="http://www.deegree.org/xml/schemas/wcts/crs_ogc_01_014.xsd"/>
  <!-- ===== -->
  <!-- element definitions -->
  <!-- ===== -->
  <!-- root element of a transform request -->
  <xs:element name="DescribeTransformationResponse"
type="DescribeTransformationResponseType"/>
  <!-- ===== -->
  <!-- type definitions -->
  <!-- ===== -->
  <!-- response type -->
  <xs:complexType name="DescribeTransformationResponseType">
    <xs:choice>
      <xs:element ref="ParameterizedTransformation" maxOccurs="unbounded"/>
    </xs:choice>
    <xs:attribute name="numberOfTransformations" type="xs:positiveInteger" use="required"/>
  </xs:complexType>
</xs:schema>

```

## A.12 Coordinate Reference System and Transformation XML Schema Definition

```

<?xml version="1.0" encoding="UTF-8"?>
<!--
  this is the XML-schema definition of the coordinate reference system and transformation generated
  by XML-Spy ver. 4 from DTD given within:
  Whiteside, A., Bobbit, J. and Nicolai, R. (eds.), "OpenGIS Recommendation Paper #01-014r5 :
  Recommended Definition Data for Coordinate References Systems and Coordinate Transformations",
  November 2001
-->

<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema" elementFormDefault="qualified">
  <xs:element name="A0" type="xs:string"/>
  <xs:element name="A1" type="xs:string"/>
  <xs:element name="A2" type="xs:string"/>
  <xs:element name="AbridgedMolodenski">
    <xs:complexType>
      <xs:sequence>
        <xs:element ref="NameSet" minOccurs="0"/>
        <xs:element ref="description"/>
        <xs:element ref="reference" minOccurs="0" maxOccurs="unbounded"/>
        <xs:element ref="formula" minOccurs="0"/>
        <xs:element ref="XaxisTranslation"/>
        <xs:element ref="YaxisTranslation"/>
        <xs:element ref="ZaxisTranslation"/>
        <xs:element ref="SemiMajorAxisDifference"/>
        <xs:element ref="FlatteningDifference"/>
      </xs:sequence>
    </xs:complexType>
  </xs:element>
  <xs:element name="AffineGeneralGeometricTransformation">
    <xs:complexType>
      <xs:sequence>
        <xs:element ref="NameSet" minOccurs="0"/>
        <xs:element ref="description"/>
        <xs:element ref="reference" minOccurs="0" maxOccurs="unbounded"/>
        <xs:element ref="formula" minOccurs="0"/>
        <xs:element ref="FirstOrdinateOfEvaluationPointInTargetCRS"/>
        <xs:element ref="SecondOrdinateOfEvaluationPointInTargetCRS"/>
        <xs:element ref="ScaleFactorFirstAxis"/>
        <xs:element ref="ScaleFactorSecondAxis"/>
        <xs:element ref="PointScaleFactor"/>
        <xs:element ref="RotationAngleFirstSourceAxis"/>
        <xs:element ref="RotationAngleSecondSourceAxis"/>
      </xs:sequence>
    </xs:complexType>
  </xs:element>
  <xs:element name="AffineGeneralParametricTransformation">
    <xs:complexType>
      <xs:sequence>
        <xs:element ref="NameSet" minOccurs="0"/>
        <xs:element ref="description"/>
        <xs:element ref="reference" minOccurs="0" maxOccurs="unbounded"/>
        <xs:element ref="formula" minOccurs="0"/>
        <xs:element ref="A0"/>
        <xs:element ref="A1"/>
        <xs:element ref="A2"/>
        <xs:element ref="B0"/>
        <xs:element ref="B1"/>
      </xs:sequence>
    </xs:complexType>
  </xs:element>

```

```

        <xs:element ref="B2"/>
      </xs:sequence>
    </xs:complexType>
  </xs:element>
  <xs:element name="AffineOrthogonalGeometricTransformation">
    <xs:complexType>
      <xs:sequence>
        <xs:element ref="NameSet" minOccurs="0"/>
        <xs:element ref="description"/>
        <xs:element ref="reference" minOccurs="0" maxOccurs="unbounded"/>
        <xs:element ref="formula" minOccurs="0"/>
        <xs:element ref="FirstOrdinateOfEvaluationPointInTargetCRS"/>
        <xs:element ref="SecondOrdinateOfEvaluationPointInTargetCRS"/>
        <xs:element ref="ScaleFactorFirstAxis"/>
        <xs:element ref="ScaleFactorSecondAxis"/>
        <xs:element ref="PointScaleFactor"/>
        <xs:element ref="RotationAngleSourceCoordAxes"/>
      </xs:sequence>
    </xs:complexType>
  </xs:element>
  <xs:element name="AlbersEqualArea">
    <xs:complexType>
      <xs:sequence>
        <xs:element ref="NameSet" minOccurs="0"/>
        <xs:element ref="description"/>
        <xs:element ref="reference" minOccurs="0" maxOccurs="unbounded"/>
        <xs:element ref="formula" minOccurs="0"/>
        <xs:element ref="LatitudeOfFalseOrigin"/>
        <xs:element ref="LongitudeOfFalseOrigin"/>
        <xs:element ref="LatitudeOfFirstStandardParallel"/>
        <xs:element ref="LatitudeOfSecondStandardParallel"/>
        <xs:element ref="EastingAtFalseOrigin"/>
        <xs:element ref="NorthingAtFalseOrigin"/>
      </xs:sequence>
    </xs:complexType>
  </xs:element>
  <xs:element name="AmericanPolyconic">
    <xs:complexType>
      <xs:sequence>
        <xs:element ref="NameSet" minOccurs="0"/>
        <xs:element ref="description"/>
        <xs:element ref="reference" minOccurs="0" maxOccurs="unbounded"/>
        <xs:element ref="formula" minOccurs="0"/>
        <xs:element ref="LatitudeOfNaturalOrigin"/>
        <xs:element ref="LongitudeOfNaturalOrigin"/>
        <xs:element ref="FalseEasting"/>
        <xs:element ref="FalseNorthing"/>
      </xs:sequence>
    </xs:complexType>
  </xs:element>
  <xs:element name="AngleFromRectifiedToSkewGrid">
    <xs:complexType>
      <xs:sequence>
        <xs:element ref="NameSet" minOccurs="0"/>
        <xs:element ref="value"/>
        <xs:element ref="AngularUnit"/>
      </xs:sequence>
    </xs:complexType>
  </xs:element>
  <xs:element name="AngularUnit">
    <xs:complexType>
      <xs:sequence>

```

```

    <xs:element ref="NameSet" minOccurs="0"/>
  <xs:choice>
    <xs:element ref="Identifier"/>
    <xs:sequence>
      <xs:choice>
        <xs:sequence>
          <xs:element ref="radiansPerUnit"/>
          <xs:element ref="unitsPerRadian" minOccurs="0"/>
        </xs:sequence>
        <xs:element ref="unitsPerRadian"/>
      </xs:choice>
      <xs:element ref="Identifier" minOccurs="0"/>
    </xs:sequence>
  </xs:choice>
</xs:sequence>
</xs:complexType>
</xs:element>
<xs:element name="AzimuthOfInitialLine">
  <xs:complexType>
    <xs:sequence>
      <xs:element ref="NameSet" minOccurs="0"/>
      <xs:element ref="value"/>
      <xs:element ref="AngularUnit"/>
    </xs:sequence>
  </xs:complexType>
</xs:element>
<xs:element name="B0" type="xs:string"/>
<xs:element name="B1" type="xs:string"/>
<xs:element name="B2" type="xs:string"/>
<xs:element name="CartesianCoordinateSystem">
  <xs:complexType>
    <xs:sequence>
      <xs:element ref="NameSet" minOccurs="0"/>
      <xs:choice>
        <xs:element ref="Identifier"/>
        <xs:sequence>
          <xs:element ref="dimensions"/>
          <xs:element ref="CoordinateAxis" maxOccurs="unbounded"/>
          <xs:element ref="Identifier" minOccurs="0"/>
        </xs:sequence>
      </xs:choice>
    </xs:sequence>
  </xs:complexType>
</xs:element>
<xs:element name="CassiniSoldner">
  <xs:complexType>
    <xs:sequence>
      <xs:element ref="NameSet" minOccurs="0"/>
      <xs:element ref="description"/>
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```

## **Annex B** (normative)

### **Conformance Test**

#### **B.1 Introduction**

Specific conformance tests for Web Coordinate Transformation Service have not yet been determined and will be added in a future revision of this specification.

## Bibliography

- [1] Daly, Martin (ed.), “OpenGIS Implementation Specification #01-009: Coordinate Transformation Services. Revision 1.00, January 2001
- [2] de La Beaujardière, Jeff (ed.), “OpenGIS Implementation Specification #02-068r3: Web Map Service Implementation Specification”, January 2002
- [3] Vretanos, Panagiotis A. (ed.), “OpenGIS Implementation Specification #01-065: Web Feature Service Implementation Specification”, May 2002
- [4] Whiteside, A., Bobbit, J. and Nicolai, R. (eds.), “OpenGIS Recommendation Paper #01-014r5 :Recommended Definition Data for Coordinate References Systems and Coordinate Transformations”, November 2001