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Editor: Arliss Whiteside

OpenGIS® Image Geopositioning Service (IGS)

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i. Preface

This is a proposed Implementation Specification for an Image Geopositioning Service (IGS) that performs triangulation and is an OGC Web Service (OWS). This service uses an Image Geopositioning Metadata GML Application Schema, which is separately specified so it can also be used by other OGC Web Services.

NOTE This service might alternately be named Image Triangulation Service, Image Registration Service, or Image Adjustment Service.

Suggested additions, changes, and comments on this draft are welcome and encouraged. Such suggestions may be submitted by email message or by making suggested changes in an edited copy of this document.

ii. Document terms and definitions

This document uses the specification terms defined in Subclause 5.3 of [OGC 06-121r3], which is based on the ISO/IEC Directives, Part 2. Rules for the structure and drafting of International Standards. In particular, the word “shall” (not “must”) is the verb form used to indicate a requirement to be strictly followed to conform to this specification.

iii. Submitting organizations

The following organizations submitted this document to the Open Geospatial Consortium Inc.

BAE Systems E&IS

iv. Document contributor contact points

All questions regarding this document should be directed to the editor or the contributors:

Name	Organization
Arliss Whiteside	BAE Systems E&IS

v. Revision history

Date	Release	Editor	Primary clauses modified	Description
2006-06-05	0.0.0	Arliss Whiteside	All	First draft
2006-07-03	0.0.0	Arliss Whiteside	3, 8.3, D	Minor improvements of SOAP encoding
2006-12-04	0.0.2	Arliss Whiteside	5.4, 6.1, 7.2, 7.3.3 to 7.3.10, 8.2.2, 8.3.4 to 8.3.7, C	General improvement
2007-03-20	0.0.3	Arliss Whiteside	4, 7.2, 7.3.1, 7.3.5, 7.3.6, 7.3.7, 7.3.9, 7.3.10, 8.3.6, C.4	Improved Triangulate operation request and response, general improvement

vi. Changes to the OGC Abstract Specification

The OpenGIS® Abstract Specification does not require any changes to accommodate the technical contents of this document.

vii. Future work

Improvements in this document are desirable for:

a) WSDL. Include WSDL definitions of SOAP encoding of all operations.

b) Examples. Extension is desirable to include more example XML documents.

c) Stereoscopic pairs of images. Evaluate pairs of images that are expected to be exploited stereoscopically.

d) Correct extracted positions. Compute coordinate Transformations that should be applied to all the positions previously extracted from the newly adjusted images using the now-superseded georeferencing coordinate Transformations.

Foreword

This document supersedes OGC Discussion Paper 06-054r1, with a different number in 2007. This document does not replace any other previous OGC document, in whole or in part. This service uses the Image Geopositioning Metadata GML Application Schema that is separately specified in [OGC 07-031].

This service is a specific Sensor geometry model adjustment service, as listed in Subclause 8.3.5.2 of ISO 19119 and OGC Abstract Specification Topic 12. This service is also a specific Geodata Registration Service, as described in Section 3.6 of OGC Abstract Specification Topic 15: Image Exploitation Services [OGC 00-115]. This service is designed to support the Register Images use case described in Section 2.1.2.5 of OGC Abstract Specification Topic 15: Image Exploitation Services [OGC 00-115].

This document includes four annexes; Annexes A, B, and D are normative, and Annex C is informative.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. The OGC shall not be held responsible for identifying any or all such patent rights.

Introduction

This document specifies the interface to an Image Geopositioning Service that adjusts the georeferencing coordinate transformations of multiple images. This adjustment is normally done using a photogrammetric triangulation process, although other methods could be used. Such triangulation adjusts the parameter values of the image georeferencing coordinate transformations, using a least-squares fitting process to measured image positions with known error statistics. Such adjustment is often required to obtain georeferencing coordinate transformations with sufficient accuracy to support image exploitation.

In addition to using existing approximate image georeferencing coordinate transformations, such triangulation uses the measured image positions of multiple object (or ground) points. Control points and tie points can be used. A control point has a measured position with position error statistics in one or more images, and a known position with error statistics in some object or “ground” Coordinate Reference System (CRS), assumed to be a GeodeticCRS. A tie point has a measured position with error statistics in two or more images, but not a known position in any object CRS.

This Image Geopositioning Service interface specifies two operations that can be requested by clients. The GetCapabilities operation allows a client to get server metadata. The Triangulate operation performs a triangulation, adjusting the parameter values of one or more image georeferencing coordinate transformations that are input with associated error statistics. The Triangulate operation inputs also include measured image positions and known object point positions, all with associated error statistics.

OpenGIS® Image Geopositioning Service (IGS)

1 Scope

This document specifies the interface to an Image Geopositioning Service (IGS) that adjusts the georeferencing coordinate transformations of multiple images. This Image Geopositioning Service (IGS) is an OGC Web Service (OWS). This service uses the Image Geopositioning Metadata GML Application Schema that is separately specified.

2 Compliance

Compliance with this specification shall be checked using all the relevant tests specified in Annex A (normative).

3 Normative references

The following normative documents contain provisions that, through reference in this text, constitute provisions of this document. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the latest edition of the normative document referred to applies.

ISO 19123:2005, *Geographic information — Schema for coverage geometry and functions*

W3C Recommendation 24 June 2003, *SOAP version 1.2, Part 1: Messaging Framework*

W3C Note, J. Barton, S. Thatte, H. Nielsen, *SOAP Messages With Attachments*, December 11, 2000

OGC 05-103, *Geographic information — Spatial referencing by coordinates* (ISO/DIS 19111)

OGC 05-105, *Geographic information — Geography Markup Language (GML)* (version 3.2, ISO/DIS 19136)

OGC 07-031, *Image geopositioning metadata GML 3.2 application schema*

OGC 06-121r3, *Web Services Common Specification*, version 1.1

NOTE This OWS Common Specification contains a list of normative references that are also applicable to this Implementation Specification.

In addition to this document, this specification includes several normative XML Schema Document files as specified in Annex B.

4 Terms and definitions

For the purposes of this specification, the definitions specified in Clause 4 of the OWS Common Implementation Specification [OGC 06-121r3] and in OpenGIS® Abstract Specification Topic 2 [OGC 05-103] shall apply. In addition, the following terms and definitions apply.

4.1
covariance matrix
detailed form of position accuracy data, sometimes called a variance-covariance matrix (adapted from OGC 00-115)

NOTE 1 For three object (or ground) coordinates, a covariance matrix is a 3 by 3 matrix, with the matrix rows and columns each corresponding to the three coordinates. For just two horizontal object coordinates, a covariance matrix is a 2 by 2 matrix, with the matrix rows and columns each corresponding to the two horizontal coordinates. Similarly, for two image coordinates, a covariance matrix is a 2 by 2 matrix, with the matrix rows and columns each corresponding to the two image coordinates.

NOTE 2 The covariance matrix cells contain the expected average values of the product of the error in the matrix row coordinate times the simultaneous error in the matrix column coordinate. For absolute accuracy, the diagonal matrix cells contain the error variances of the corresponding object (or ground) coordinates, or the squares of the standard deviations. The off-diagonal cells contain the covariances between the errors in the corresponding object coordinates; these covariances will be zero when the errors in different coordinates are not statistically correlated. All covariance matrices are symmetrical, meaning that the same cell values appear on both sides of the diagonal cells.

4.2
georeferencing transformation
coordinate transformation that can be used to convert grid coordinate values to values of coordinates referenced to a coordinate reference system that is related to the earth by a datum (adapted from ISO 19123)

4.3
image geopositioning
adjustment of the parameter values of image georeferencing coordinate transformations to produce correct coordinates in a coordinate reference system that is related to the earth

4.4
transformation
approximate transformation of position coordinates from one Spatial Reference System (SRS) to another

NOTE For example, this term is used when the transformation coefficients are determined by least squares adjustment. This term is strictly used only when the transformation is known only approximately. This term is loosely used when the transformation is known either approximately or exactly.

4.5
triangulation
adjustment of the parameter values of two or more image georeferencing coordinate transformations by least-squares fitting to measured image points and usually known object (or ground) control points

4.6
photogrammetry
science of mensuration and geometric adjustment of an aerial photograph or satellite image (adapted from OGC 00-115)

NOTE 1 Photogrammetry requires a mathematical model of the image formation process, computation of the internal geometry of an image, and subsequent correction of imagery based upon the ground relationship for every part of the image. This correction of imagery is based on computational algorithms and measurement of positions in an image.

NOTE 2 Effective photogrammetry makes use of ground control points by which photographs are carefully compared and registered to the locations and characteristics of features identified in ground-level surveys.

5 Conventions

5.1 Abbreviated terms

CRS	Coordinate Reference System
GML	Geography Markup Language
HTTP	Hypertext Transfer Protocol
IGS	Image Geopositioning Service
IGM	Image Geopositioning Metadata
ISO	International Organization for Standardization
KVP	Keyword Value Pair
OGC	Open Geospatial Consortium
OWS	OGC Web Service, or Open Web Service
SOAP	Simple Object Access Protocol (no longer used)
TBD	To Be Determined
TBR	To Be Reviewed
UML	Unified Modeling Language
URI	Universal Resource Identifier
URL	Uniform Resource Locator
XML	Extensible Markup Language

5.2 UML notation

The diagrams that appear in this specification are presented using the Unified Modeling Language (UML) static structure diagram, as described in Subclause 5.2 of [OGC 06-121r3].

5.3 Used parts of other documents

This document uses significant parts of document [OGC 06-121r3]. To reduce the need to refer to that document, this document copies some of those parts with small

modifications. To indicate those parts to readers of this document, the largely copied parts are shown with a light grey background (15%).

5.4 Platform-neutral and platform-specific specifications

As specified in Subclause 5.4 of OWS Common [OGC 06-121r3], this document includes both platform-neutral and platform-specific specifications.

EXAMPLES 1 Platform-neutral specifications are contained in Subclauses 7.2.1, 7.3.2, 7.3.5, 8.3.2, and 8.3.4.

EXAMPLES 2 Platform-specific specifications for XML encoding are contained in Subclauses 7.2.3, 7.3.3, 7.3.9, 8.2.4, and 8.3.6.

5.5 Data dictionary tables

The UML model data dictionary is specified herein in a series of tables, as described in Subclause 5.5 of OWS Common [OGC 06-121r3].

6 Image Geopositioning Service overview

6.1 Geopositioning needs

For most applications of object (or ground) positions extracted from images, it is highly desirable to maximize the accuracy of those positions, by using georeferencing coordinate transformations that are as accurate as possible. In many cases, high relative accuracy is needed, with respect to positions previously or subsequently measured, in other images or by surveying (including by GPS). For many of those positions, it is also highly desirable to produce explicit estimates of the position absolute and relative accuracy, where those accuracy estimates are as accurate as possible. One such application is producing large scale maps.

Photogrammetric triangulation of images, also called aerial triangulation, block triangulation, or analytical triangulation, is a widely-known and frequently-used process for improving image georeferencing. In some cases, the absolute and relative accuracies are improved by a factor of ten or more. Triangulation is the subject of Section 11.2 (more than 40 pages) in the Fifth Edition (2004) of the Manual of Photogrammetry, published by the American Society for Photogrammetry and Remote Sensing. (Triangulation was the subject of several pages in the Third Edition [1966] of this Manual of Photogrammetry.)

This Image Geopositioning Service is a specific Geodata Registration Service as described in Section 3.6 of OGC Abstract Specification Topic 15: Image Exploitation Services [OGC 00-115]. This service is designed to perform Step 10 in the Register Images use case described in Section 2.1.2.5 of that document. That Register Images use case performs Step 5 in the Prepare Feature Source Package use case described in Section 2.1.2.4, which performs Step 1 in the Produce Feature Product use case described in Section 2.1.2.1.

This Image Geopositioning Service is also designed to perform Step 11 in the “Provide images to archives use case” described in Subclause A.3.2 of “OWS 1.2 image handling

requirements" [OGC 04-052]. That use case supports Step 3 in the "Agricultural irrigation use case" described in Subclause A.4.2 of that document.

Although not explicitly identified, use of a Geodata Registration Service will often be needed in many other use cases described in documents [OGC 00-115] and [OGC 04-052]. In [OGC 00-115], those other use cases include the Farmer, Prospective Home Buyer, and Soldier use cases described in Section 2.1.1. In [OGC 04-052], those other use cases include the Natural Resources, Hurricane Evacuation, and European Union Crop Monitoring use cases also described in Subclause A.4.

NOTE For brevity, those use cases are not copied in this document.

Many applications of the Web Coverage Service (WCS) version 1.1 will use image georeferencing coordinate transformations, and those transformations often should be as accurate as practical. Annex H in WCS 1.1 [OGC 06-083r8] specifies 10 use cases, and 8 of these use cases use georeferencing coordinate transformations for image coverages. Use cases 4 and 5 require output of the georeferencing coordinate transformation with the output image coverage. Use cases 9 and 10 require the WCS to perform georectification, which requires use of the georeferencing coordinate transformation for the stored image. Use cases 1, 2, 6, and 7 use a georectified stored image, and such image georectification requires use of a georeferencing coordinate transformation.

6.2 Image geopositioning function

The specified Image Geopositioning Service (IGS) adjusts the georeferencing coordinate transformations of one or more images. This adjustment is done to produce more accurate georeferencing coordinate transformations for each of these images, plus accurate estimates of the accuracy of positions extracted using those georeferencing coordinate transformations. This IGS uses the Image Geopositioning Metadata GML Application Schema that is separately specified in document [OGC 07-031].

This adjustment of georeferencing coordinate transformations is normally done using a photogrammetric triangulation process, although other methods could be used. Such triangulation adjusts the parameters of the image georeferencing coordinate transformations, using a least-squares fitting process to measured image positions. This triangulation starts with an existing approximate image georeferencing coordinate transformation for each image, with parameter error statistics for the parameters that can be adjusted.

In addition to using approximate image georeferencing coordinate transformations, such triangulation uses the measured image positions of multiple object (or ground) points. Control points and tie points can be used. A control point has a measured position with known position error statistics in one or more images, and a known position with error statistics in some object or "ground" Coordinate Reference System (CRS). Such an object CRS is assumed to be a GeodeticCRS. A tie point has a measured position with error statistics in two or more images, but not a known position in any object (CRS).

NOTE 1 If a control point has a known position in a ProjectedCRS, that position can be converted to a GeodeticCRS, together with its error statistics.

The error statistics are in the form of covariance matrices, also called variance-covariance matrices, together with the (most-likely) values to which the covariance matrices apply. The matrices contain the variance of each measured and estimated value, and the covariances between these values. These measured and/or estimated values include point position coordinates in images and in object CRSs. They also include various parameters in georeferencing coordinate transformations, including the camera 3D position coordinates and 3D orientation angles.

NOTE 2 Such covariance matrices for single point coordinates are described in Table D.33 of [ISO/TS 19138 draft n1934].

6.3 Operations

The IGS interface (currently) specifies two operations that can be requested by a client and performed by an IGS server. Those operations are:

a) Triangulate (required implementation by servers) – This operation performs triangulation computations, adjusting the parameters of one or more image georeferencing coordinate transformations that are input with associated parameter error statistics. The Triangulate operation inputs also include the measured image positions and known object point positions, all with associated position error statistics.

b) GetCapabilities (required implementation by servers) – This operation allows a client to request and receive back a service metadata (or Capabilities) document that describe the abilities of the specific server implementation. This operation also supports negotiation of the specification version being used for client-server interactions.

These operations have many similarities to other OGC Web Services, including the WMS, WFS, and WCS. Many of these interface aspects that are common with other OWSs are thus specified in the OpenGIS® Web Services Common Implementation Specification [OGC 06-121r3]. Many of these common aspects are normatively referenced herein, instead of being repeated in this specification.

Figure 2 is a simple UML diagram summarizing the IGS interface. This class diagram shows that the ImageGeopositioningService interface class inherits the getCapabilities operation from the OGCWebService interface class, and adds the “triangulate” operation. (This capitalization of names uses the OGC/ISO profile of UML.) A more complete UML model of the IGS interface is provided in Annex C (informative).

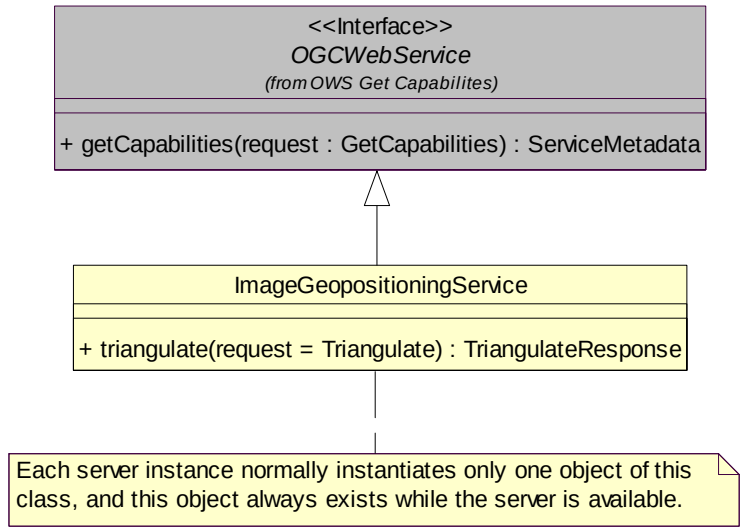

Figure 1 — IGS interface UML diagram

NOTE In this UML diagram, the request and response for each operation is shown as a single parameter that is a data structure containing multiple lower-level parameters, which are discussed in subsequent clauses. The UML classes modelling these data structures are included in the complete UML model in Annex C.

6.4 Operation request encoding

The encoding of operation requests shall use SOAP, HTTP GET with KVP encoding, and HTTP POST with XML encoding as specified in Clause 11 of [OGC 06-121r3]. Table 1 summarizes the two Service operations and their encoding methods defined in this specification.

Table 1 — Operation request encoding

Operation name	Request encoding
GetCapabilities (mandatory)	KVP and optional SOAP, XML
Triangulate (mandatory)	SOAP and optional XML

Each of these operations is described in more detail in subsequent clauses.

7 Triangulate operation (mandatory)

7.1 Introduction

The mandatory Triangulate operation allows IGS clients to request triangulation computations, and receive back the results. The parameters of one or more image georeferencing coordinate transformations are input with associated parameter error statistics, and similar adjusted data is output. The Triangulate operation inputs also include measured image positions and known object point positions, all with associated position error statistics. The estimated actual image and object positions resulting from the triangulation are also output, with associated position error statistics.

NOTE If the image georeferencing coordinate transformation of only one image is input for adjustment, this is normally called image “resection” instead of “triangulation”.

7.2 Triangulate operation request

7.2.1 Triangulate request parameters

A request to perform the Triangulate operation shall use the data structures shown in the UML diagrams in Figure 2 and Figure 3. The attributes and associations of the four new classes shall include the parameters and data structures listed and defined in Table 2 through Table 5.

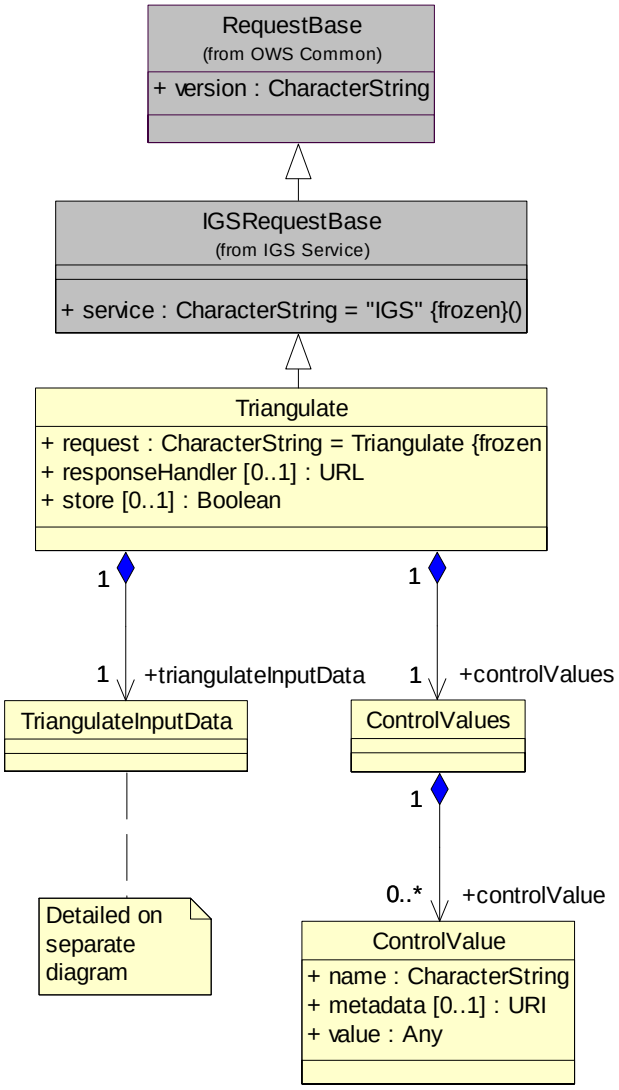

Figure 2 — Triangulate operation request UML diagram

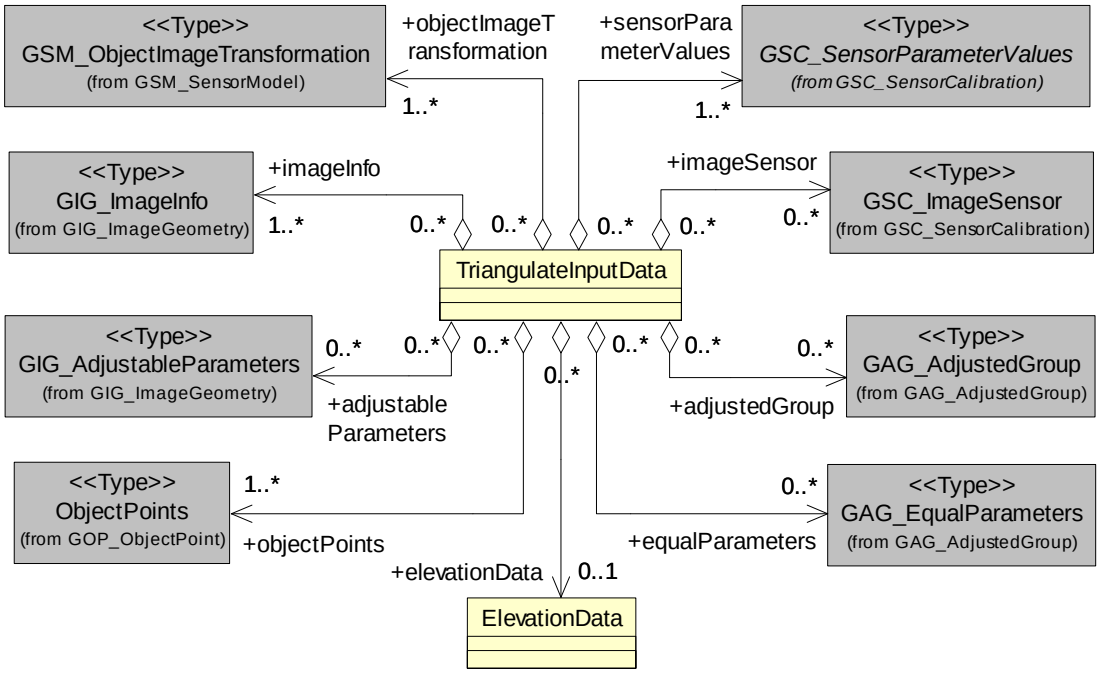

Figure 3 — TriangulateInputData UML diagram

NOTE 1 To reduce the need for readers to refer to other documents, the first three parameters listed below are largely copied from Table 21 in Subclause 9.2.1 of [OGC 06-121r3].

Table 2 — Parameters in Triangulate operation request

Names	Definition	Data type and values	Multiplicity and use
service service	Service type identifier	Character String type, not empty Value is OWS type abbreviation, namely "IGS"	One (mandatory)
request request	Operation name	Character String type, not empty Value is operation name, namely "Triangulate"	One (mandatory)
version version	Specification version for operation	Character String type, not empty Value is specified by each Specification and Schemas version	One (mandatory)
triangulateInputData TriangulateInputData	Input data to this triangulation execution [a]	TriangulateInputData data structure, see Table 5	One (mandatory)
controlValues ControlValues	Values of quantities to be used to control triangulation computations	ControlValues data structure, see Table 3	One (mandatory)
store store	Specifies if transformed data to be stored as remote resource	Boolean Values are: true or false	Zero or one (optional) Default is false (return directly in response)
responseHandler ResponseHandler	Address to respond to when server has completed processing this operation request	URL	Zero or one (optional) Include to process operation request asynchronously [b]

a This input data shall include the approximate georeferencing coordinate transformation parameter values, with parameter error statistics, as specified in Table 5. This input data shall also include object point positions in image coordinates and optionally in object coordinates, with position error statistics, as also specified in Table 5.

b When this parameter is omitted in the operation request, this operation shall be executed synchronously and immediately by the server, with the operation response returned to the client following operation execution. When this parameter is included, this operation shall be processed asynchronously by the server. In that case, the server shall return an operation acknowledgement to the client immediately following operation acceptance. When operation execution is later completed, the (normal or exception) operation response shall be sent by the server to the response handler address provided by this parameter value.

Table 3 — Parts of ControlValues data structure

Names	Definition	Data type	Multiplicity and use
controlValue ControlValue	Value of one server-specific quantity to be used to control triangulation computations	ControlValue data structure, see Table 4	One or more (optional) Include when default value not desired [a]

a Each server-specific control quantity should have a default value that often allows the triangulation computations to be completed.

Table 4 — Parts of ControlValue data structure

Names	Definition	Data type	Multiplicity and use
name name	Name or identifier of this server-specific control quantity	CharacterString type [a]	One (mandatory)
metadata metadata	Reference to metadata about this value [b]	URI type	Zero or one (optional) Include when needed or useful for this value
value (anonymous)	Value of this server-specific control quantity	Any type [c]	One (mandatory)

a The name of each allowed server-specific control quantity shall be clearly specified by each server, in service metadata (Capabilities) document.

b May be used like gml:srsName for gml:pos and other geometry values.

c The value type, units, and allowed range of each allowed server-specific control quantity shall be clearly specified by each server, in service metadata (Capabilities) document.

The contents associated with the TriangulateInputData class in the Triangulate operation request shall include the data packages with the package types listed in Table 5. Most of these data package types are specified in Clause 13 of the Image Geopositioning Metadata GML Application Schema [OGC 07-031].

Table 5 — Associations from TriangulateInputData

Package type (modification)	Include package for each	Each package includes objects
ObjectImageTransformation (to be modified)	Image to be adjusted in this triangulation Include copy of best previous transformation, modified if needed to reference desired AdjustableParameters for new transformation	One igm:ObjectImageTransformation, containing: One igm:ImageParameterValues,[a] containing: Zero to two gml:Point or gml:Curve All sensor-model-specific objects associated from aboveigm:ImageParameterValues[b] Zero or one gml:Polygon footprint Zero or one igm:ImageAccuracySummary[f] Zero or more adjusted igm:ImagePosition, each containing: (not used) One gml:Point Zero or one igm:CovariuanceMatrix Zero or one igm:Matrix[g]
ImageInfo (to be updated)	Image to be adjusted in this triangulation Include latest version	One igm:ImageInfo, containing: One or more measured igm:ImagePosition, each containing: One gml:Point Zero or one igm:CovariuanceMatrix[g] Zero or one igm:Matrix[g]
SensorParameterValues (to be modified only when sensor adjusted)	Package associated from ImageParameterValues of any image to be adjusted in this triangulation Include best previous adjustment	One igm:SensorParameterValues,[a] containing: All sensor-model-specific objects associated from above igm:SensorParameterValues[b]
ImageSensor (to be updated only when sensor adjusted)	SensorParameterValues to be adjusted in this triangulation (if any) Include latest version	One igm:ImageSensor
AdjustedGroup (not changed or output, but new file to be produced)	AdjustedGroup associated from first ImageParameterValues for each image to be adjusted in this triangulation[c]	One igm:AdjustedGroup, containing: One igm:CovarianceMatrix One igm:Matrix Zero or one igm:AdjustmentSummary

Package type (modification)	Include package for each	Each package includes objects
ObjectPoints (to be used and not changed)	One or more, containing all control, check, and tie point to be used in this triangulation[e]	One igm:ObjectPoints, containing: One or more igm:ObjectPoint, each containing: Zero or one measured igm:ObjectPosition, containing: One gml:Point One igm:CovariuanceMatrix One igm:Matrix
AdjustableParameters (to be used and not changed)	AdjustableParameters associated from ImageParameterValues of any image to be adjusted in this triangulation[h]	One igm:AdjustableParameters
EqualParameters (to be used and not changed)	EqualParameters to be used in this triangulation	One igm:EqualParameters
ElevationCoverage (to be used and not changed)	Include when elevation data to be used to estimate tie point and horizontal control point vertical coordinates, until convergence automatically detected	

a Since this class is abstract, objects shall be of one of the multiple non-abstract subclasses of this class.

b For some of these sensor parameters, one file shall be attached providing parameter values that are not encoded in XML.

c The AdjustedGroup associated from the first ImageParameterValues for each image shall be included to provide covariance data for the initial image parameter values. Alternately, the first ImageParameterValues for each image may instead be associated with a predefined CovarianceMatrix that provides default values. In this case, no AdjustedGroup need be included in the TriangulateInputData.

d The AdjustedGroup associated from the first SensorParameterValues for each sensor shall be included when these sensor parameters are being adjusted in this triangulation, to provide covariance data for the initial sensor parameter values. Alternately, the first ImageParameterValues for each image may instead be associated with a predefined CovarianceMatrix that provides default values. In this case, no AdjustedGroup need be included in the TriangulateInputData.

e For a control or check point, the igm:ObjectPosition shall be for the measured position. For a tie point, there shall be no igm:ObjectPosition.

f The conditional igm:ImageAccuracySummary is not needed and will not be used, but may be included when (already) present.

g When this igm:CovarianceMatrix represents multiple image positions, it may be included with only one of those positions.

h A default AdjustableParameters may be predefined and referenced from the ImageParameterValues for one or more images. In this case, this AdjustableParameters can be omitted in the TriangulateInputData.

7.2.2 Implementation requirements

The Triangulate operation shall be implemented by all IGS servers and clients. The "Multiplicity and use" columns in Table 2 through Table 4 specify the optionality of each listed parameter and data structure in the Triangulate operation request. All the "mandatory" parameters and data structures shall be implemented by all IGS clients, using a specified value(s). Similarly, all the "mandatory" parameters and data structures

shall be implemented by all IGS servers, checking that each request parameter or data structure is received with any specified value(s).

All the “optional” parameters and data structures, in the Triangulate operation request, should be implemented by all IGS clients using specified values, when that parameter or data structure applies. The “store” and “responseHandler” parameters shall be implemented by all IGS servers. All the other “optional” parameters and data structures shall be implemented by all IGS servers to which that parameter or data structure applies.

The TriangulateInputData associations (listed in Table 5) shall be implemented, by all servers and clients, to the ObjectImageTransformation, ImageInfo, SensorParameterValues, and ObjectPoints package types, and should be implemented to the AdjustedGroup and AdjustableParameters package types. The associations to the ImageSensor, EqualParameters, and ElevationCoverage shall be implemented only if the corresponding triangulation ability is implemented by a server or is used by a client.

7.2.3 Triangulate request XML encoding (optional)

IGS servers may implement HTTP POST transfer of the Triangulate operation request, using XML encoding only. The XML encoding of a Triangulate operation request shall be as specified for the Triangulate element in the attached normative XML Schema Document igsTriangulate.xsd (the first parts).

The contents of the packages associated from the TriangulateInputData element shall be encoded in XML as specified in the Image geopositioning metadata GML application schema [OGC 07-031].

7.2.4 Triangulate request SOAP encoding (mandatory)

IGS servers shall implement SOAP version 1.2 transfer of the Triangulate operation request as specified in Annex D, using the XML encoding specified above.

7.2.5 Triangulate request encodings

The encoding of a Triangulate operation request consists of a Triangulate XML document that is packaged with all the data that is referenced (but not encoded inline) in the TrianlulateInputData element. Referenced data shall be packaged with the Triangulate document using either a MIME multipart message (for XML requests) or as a SOAP message with attachments (for SOAP requests). The TriangulateInputData shall reference the other parts of the MIME multi-part message (or SOAP attachments) as indicated in 7.3.8 below.

Triangulate requests transferred using MIME multipart shall be encoded according to [IETF RFC 2387], with the first part containing an XML encoded Triangulate element. Every part of the multipart message shall have a content-id. The part containing the Triangulate element shall have a content-id equal to “urn:ogc:igs:0.0:triangulate”; other parts may have any content-id values. The TriangulateInputData element shall reference other parts of the multipart message by their content-id values, prefixed by “cid**:**”.

EXAMPLE If a multipart message contains a part with “`content-id:ottawa_temp.tiff`”, then the InputData element would reference that part with the following XML fragment:

```
<Reference xlink:href="cid:ottawa_temp.tiff"/>
```


NOTE Using prefixes other than “cid:”, the InputData element can, but shall not, reference resources external to the MIME multipart message.

7.3 Triangulate operation response

7.3.1 Introduction

The Triangulate operation shall be executed in one of two ways, depending on the presence or absence of the ResponseHandler parameter in the operation request. If the ResponseHandler parameter is not included, then the IGS server shall execute the Triangulate operation immediately and then respond to the client with a TriangulateResponse message. When an IGS server encounters an error while immediatley performing a Triangulate operation, it shall return an exception report message.

If the ResponseHandler parameter is included in the Triangulate operation request, then the IGS server should verify the request syntax and immediately respond to the client with an Acknowledgment message. When an IGS server encounters an error while immediately checking a Triangulate operation request, it shall immediately return an exception report message. Later, after the server has executed the Triangulate operation, it shall generate a TriangulateResponse message and send it to the URL specified by the ResponseHandler parameter, using the protocol encoded therein. Common protocols are *ftp* for sending the response to a ftp server and *mailto* which may be used to send the response to an email address. When an IGS server encounters an error after sending an Acknowledgment message, it shall return an exception report message to the ResponseHandler.

7.3.2 Acknowledgement message contents

When the Triangulate operation is performed asynchronously, the immediate response to a valid operation request shall be an Acknowledgement message that shall use.the data structure shown in the UML diagram in Figure 4. The attributes and associations of the new class shall include the parameters and data structures listed and defined in Table 6.

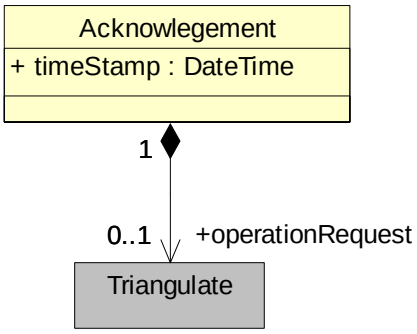

Figure 4 — Acknowledgement UML diagram

Table 6 — Contents of Acknowledgement data structure

Names [a]	Definition	Data type	Multiplicity and use
timeStamp TimeStamp	Data and time this Acknowledgement message generated	DateTime type	One (mandatory)
operationRequest OperationRequest	Copy of Triangulate operation request being acknowledged	Triangulate request data structure, see Table 2	Zero or one (optional) Include when expected to be useful to clients
a The name capitalization rules being used here are specified in Subclause 11.6.2 of [OGC 06-121r3].			

7.3.3 Acknowledgement message XML encoding

IGS servers may implement XML encoded transfer of the Triangulate operation Acknowledgement response. An Acknowledgement message shall be encoded in XML as specified by the following schema fragment:

```
   <element name="Acknowledgement" type="igs:AcknowledgementType">
      <annotation>
         <documentation>XML encoded acknowledgement of Triangulate
operation request. </documentation>
      </annotation>
   </element>
   <!-- ========================================================== -->
   <complexType name="AcknowledgementType">
      <sequence>
         <element name="TimeStamp" type="dateTime">
            <annotation>
               <documentation>Data and time this Acknowledgement
message generated. </documentation>
            </annotation>
         </element>
         <element name="OperationRequest" type="igs:TriangulateType"
minOccurs="0">
            <annotation>
               <documentation>Copy of Triangulate operation request
being acknowledged. This copy should be included when expected to be
useful to clients. </documentation>
            </annotation>
         </element>
      </sequence>
   </complexType>
```

EXAMPLE An example minimum Acknowledgement message XML encoded is:

```
<?xml version="1.0" encoding="UTF-8"?>
<Acknowledgement>
   <TimeStamp>2006-12-01T15:00:00</TimeStamp>
</Acknowledgement>
```

7.3.4 Acknowledgement message SOAP encoding

IGS servers that implement SOAP transfer of Triangulate operation requests shall also implement SOAP version 1.2 transfer of the Triangulate operation Acknowledgement response as specified in Annex D, using the XML encoding specified above.

EXAMPLE An example Acknowledgement message XML encoded in a SOAP envelope is:

```
<?xml version="1.0" encoding="UTF-8"?>
<env:Envelope>
    <env:Body>
        <Acknowledgement>
            <TimeStamp>2006-12-01T15:00:00</TimeStamp>
        </Acknowledgement>
    </env:Body>
</env:Envelope>
```

7.3.5 TriangulateResponse message contents

The normal response to a valid Triangulate operation request shall be a TriangulateResponse data structure as shown in the UML diagram in Figure 5. This OperationResponse shall be associated with the adjusted georeferencing coordinate transformation parameter values, with parameter error statistics, as specified in [OGC 07-031]. In addition, this OperationResponse shall be associated with the estimated object position coordinates for all object points, computed using the image positions and the final adjusted image parameter values. More precisely, this TriangulateResponse shall be associated with the IGM packages with the package types listed in Table 7.

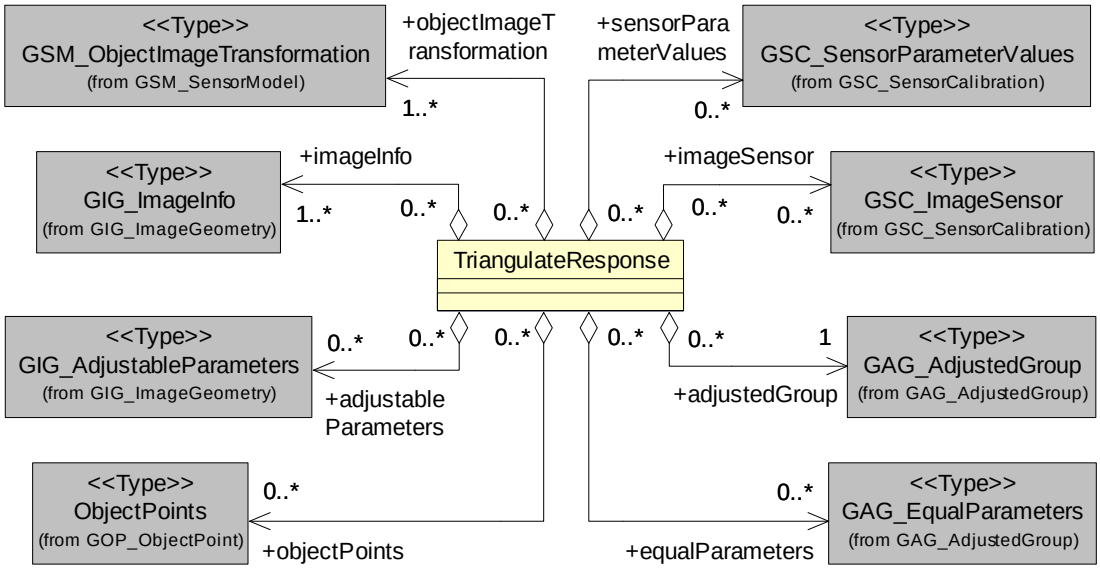

Figure 5 — TriangulateResponse UML diagram

Table 7 — Associations from TriangulateResponse

Package type (modification)	Include package for each	Each package includes objects
AdjustedGroup (new file produced)	One for this triangulation	One igm:AdjustedGroup, containing: One igm:CovarianceMatrix One igm:Matrix One igm:AdjustmentSummary One gml:Polygon footprint One or more adjusted igm:ObjectPosition computed, each containing:[c] One gml:Point Zero or one igm:CovarianceMatrix[d] Zero or one igm:Matrix[d]
ObjectImageTransformation (largely changed)	Image adjusted in this triangulation	One igm:ObjectImageTransformation, containing: One igm:ImageParameterValues,[a] containing: Zero to two gml:Point or gml:Curve All sensor-model-specific objects associated from above igm:ImageParameterValues[b] One ImageAccuracySummary One gml:Polygon footprint Zero or more adjusted igm:ImagePosition computed, each containing:[c] One gml:Point Zero or one igm:CovarianceMatrix[d] Zero or one igm:Matrix[d]
ImageInfo (updated)	Image adjusted in this triangulation	One igm:ImageInfo Zero or more measured igm:ImagePosition, each containing: One gml:Point Zero or one igm:CovarianceMatrix[d] Zero or one igm:Matrix[d]
SensorParameterValues (new file when sensor adjusted)	SensorParameterValues adjusted in this triangulation (if any)	One igm:SensorParameterValues[a] All sensor-model-specific objects associated from above igm:SensorParameterValues[b]
ImageSensor (updated when sensor adjusted)	SensorParameterValues adjusted in this triangulation (if any)	One igm:ImageSensor

Package type (modification)	Include package for each	Each package includes objects
ObjectPoints (unchanged)	Optional, may include one or more	One igm:ObjectPoints, containing: One or more igm:ObjectPoint, each containing: Zero or one measured igm:ObjectPosition, containing: One gml:Point One igm:CovariuanceMatrix One igm:Matrix
AdjustableParameters (unchanged)	Optional, may include packages associated from ImageParameterValues of any image adjusted in this triangulation	One igm:AdjustableParameters
EqualParameters (unchanged)	Optional, may include EqualParameters used in this triangulation	One igm:EqualParameters

a Since this class is abstract, objects shall be of one of the multiple non-abstract subclasses of this class.

b For some of these image and sensor parameters, one file shall be attached providing parameter values that are not encoded in XML.

c For all types of points, the igm:ObjectPosition and igm:ImagePosition shall be computed following triangulation, if possible.

d When this igm:CovarianceMatrix represents multiple object or image positions, it may be included with only one of those positions.

7.3.6 Implementation requirements

The TriangulateResponse associations (listed in Table 7) shall be implemented, by all servers and clients, to the AdjustedGroup, ObjectImageTransformation, and ImageInfo package types. The associations to the SensorParameterValues and ImageSensor package types shall be implemented only if the ability to adjust sensor parameters is implemented by a server or is used by a client. The asociations to the ObjectPoints, AdjustableParameters, EqualParameters, and non-adjusted SensorParameterValues package types are optional implementation by servers.

7.3.7 TriangulateResponse encodings

The encoding of a Triangulate operation response consists of an TriangulateResponse XML document that is packaged according to the request encoding and the value of the “store” parameter (see Table 2). IGS servers shall implement response encodings according to Table 8.

Table 8 — TriangulateResponse encodings

Request encoding	store=true [a]	store=false *(default)* [a]
XML (plain)	TriangulateResponse referencing packages	TriangulateResponse in a MIME Multipart message (see 7.3.8)
SOAP	TriangulateResponse referencing packages, in a SOAP envelope (see 7.3.9)	TriangulateResponse in a SOAP envelope with Attachments (see 7.3.9)

a Applies only when the server supports the "store" parameter (see Subclause 7.2).

b Some or all of the associated IGM packages may be encoded inline within the TriangulateResponse XML element. If all associated IGM packages are encoded inline, there is no need for a MIME Multipart message or a SOAP envelope with Attachments.

If the "store" parameter has the value "true", the server shall store the result file(s) at URL-addressable location(s) of its choosing, and return only the TriangulateResponse data structure (within a SOAP envelope in the case of a SOAP request) with references to the other files as indicated in Subclause 7.3.8 below.

When the "store" parameter is absent or has the value "false", the server shall transfer the TriangulateResponse element to the client. If not all associated IGM packages are encoded inline within the TriangulateResponse XML element, either a MIME multipart message (for XML requests) or a SOAP message with attachments (for SOAP requests) shall be used. The TriangulateResponse shall reference the other parts of the MIME multi-part message (or SOAP attachments) as specified in Subclause 7.3.8 below. If all associated IGM packages are encoded inline, a plain MIME or SOAP message shall be used.

7.3.8 MIME multipart response

Triangulate responses transferred using MIME multipart shall be encoded according to [IETF RFC 2387], with the first part containing an XML encoded TriangulateResponse element. Every part of the multipart message shall have a content-id. The part containing the TriangulateResponse element shall have a content-id equal to "urn:ogc:igs:0.0:triangulateResponse"; other parts may have any content-id values. The TriangulateResponse element shall reference other parts of the multipart message by their content-id values, prefixed by "cid**:**".

EXAMPLE If a multipart message contains a part with "`content-id:ottawa_temp.tiff`", then the OperationResponse element would reference that part with the following XML fragment:

```
<Reference xlink:href="cid:ottawa_temp.tiff"/>
```

NOTE Using prefixes other than "cid:", the OperationResponse element can, but shall not, reference resources external to the MIME multipart message.

7.3.9 TriangulateResponse XML encoding (optional)

IGS servers that implement (plain) XML transfer of Triangulate operation requests shall respond to a valid Triangulate operation request with an XML encoded TriangulateResponse message, as specified by the XML schema fragment for the TriangulateResponse element in the attached normative XML Schema Document named igsTriangulate.xsd. The IGM data packages associated with that message shall be encoded in XML as specified in [OGC 07-031].

7.3.10 OperationResponse message SOAP encoding (mandatory)

IGS servers that implement SOAP transfer of Triangulate operation requests shall also implement SOAP version 1.2 transfer of the corresponding Triangulate operation responses. These operation responses shall be encoded as specified in Annex D. When the "store" parameter has the value "true", the body of the SOAP envelope shall contain one XML encoded TriangulateResponse element. That element may contain one or more references to URLs of files containing output IGM packages.

When the "store" parameter is absent or has the value "false", responses to Triangulate SOAP requests shall be encoded as SOAP with Attachments as defined in [W3C Note] (but using SOAP 1.2 rather than SOAP 1.1). These responses shall consist of MIME multipart messages, as specified in 7.3.7, with the TriangulateResponse element contained within a SOAP 1.2 envelope, encoded as specified in Annex D.

7.3.11 Triangulate operation exceptions

When an IGS server encounters an error while performing a Triangulate operation, it shall return an exception report message as specified in Subclause 7.4 of [OGC 06-121r3]. The allowed standard exception codes shall include those listed in Table 9. For each listed exceptionCode, the contents of the "locator" parameter value shall be as specified in the right column of Table 9.

NOTE To reduce the need for readers to refer to other documents, the first four values listed below are copied from Table 20 in Subclause 8.3 of [OGC 06-121r3].

Table 9 — Exception codes for Triangulate operation

exceptionCode value	Meaning of code	"locator" value
MissingParameterValue	Operation request does not include a parameter value, and this server did not declare a default value for that parameter	Name of missing parameter
InvalidParameterValue	Operation request contains an invalid parameter value	Name of parameter with invalid value
OptionNotSupported	Request is for an option that is not supported by this server	Identifier of option not supported
NoApplicableCode	No other exceptionCode specified by this service and server applies to this exception	None, omit "locator" parameter
DidNotConverge	Iterative computation did not converge	None, omit "locator" parameter
ComputationError	Computation error occurred during computation, such as overflow or underflow	None, omit "locator" parameter

In addition to the exceptionCode values listed above, each IGS server may define and use server-specific exceptionCode values. Those server-specific exceptionCode values and their meanings shall be encoded using the ows:Parameter element in the OperationsMetadata section of the service metadata (Capabilities) document, see Subclause 8.3.3.

8 GetCapabilities operation (mandatory)

8.1 Introduction

The mandatory GetCapabilities operation allows clients to retrieve service metadata from a server. The response to a GetCapabilities request shall be an XML document containing service metadata about the server, including the coordinate Transformation, GeodeticCRS, and other computational abilities of this IGS server. This clause specifies the XML document that an IGS server shall return to describe its capabilities.

8.2 GetCapabilities operation request

8.2.1 GetCapabilities request contents

The GetCapabilities operation request shall be as specified in Subclauses 7.2 and 7.3 of [OGC 06-121r3]. The value of the “service” parameter shall be “IGS”. The allowed set of service metadata (or Capabilities) XML document section names and meanings shall be as specified in Tables 3 and 7 of [OGC 06-121r3]. For an IGS, the Contents section will contain metadata about the coordinate transformation and CRS abilities of this server (not about data that can be accessed from this server).

8.2.2 Implementation requirements

The GetCapabilities operation shall be implemented by all IGS servers and clients. The “Multiplicity and use” column in Table 1 of [OGC 06-121r3] specifies the optionality of each listed parameter in the GetCapabilities operation request. Table 10 specifies the implementation of those parameters by IGS clients and servers.

Table 10 — Implementation of parameters in GetCapabilities operation request

Names	Multiplicity	Client implementation	Server implementation
service service	One (mandatory)	Each parameter shall be implemented by all clients, using specified value	Each parameter shall be implemented by all servers, checking that each parameter is received with specified value
request request	One (mandatory)		
acceptVersions AcceptVersions	Zero or one (optional)	Should be implemented by all software clients, using specified values	Shall be implemented by all servers, checking if parameter is received with specified value(s)
sections Sections	Zero or one (optional) [b]	Parameter may be implemented by each client If parameter not provided, shall expect default response If parameter provided, shall allow default or specified response	Parameter may be implemented by each server If parameter not implemented or not received, shall provide default response If parameter implemented and received, shall provide specified response
updateSequence updateSequence	Zero or one (optional)	Each parameter should not be implemented by each client Client shall allow and expect default response	Each parameter should not be implemented by each server If parameter not implemented, shall provide default response
acceptFormats AcceptFormats	Zero or one (optional)		

8.2.3 GetCapabilities request KVP encoding (mandatory)

All IGS servers shall implement HTTP GET transfer of the GetCapabilities operation request, using KVP encoding as specified in Subclause 7.2.3 of [OGC 06-121r3].

EXAMPLE To request a IGS capabilities document, a client could issue the following KVP encoded GetCapabilities operation request with near-minimum contents:

```
www.baesystems.com/webservice/igs&service=IGS&request=getCapabilities
```

8.2.4 GetCapabilities request XML encoding (optional)

IGS servers may implement HTTP POST transfer of the GetCapabilities operation request, using XML encoding only. The following schema fragment specifies the contents and structure of a GetCapabilities operation request encoded in XML:

```
   <element name="GetCapabilities">
      <annotation>
         <documentation>Request to an IGS server to perform the
GetCapabilities operation. This operation allows a client to retrieve a
Capabilities XML document providing metadata for the specific IGS
server. In this XML encoding, no "request" parameter is included, since
the element name specifies the specific operation. </documentation>
      </annotation>
      <complexType>
         <complexContent>
            <extension base="ows:GetCapabilitiesType">
               <sequence/>
```



```
                <attribute name="service" type="ows:ServiceType"
use="required" fixed="IGS"/>
            </extension>
        </complexContent>

    </complexType>
</element>
```

EXAMPLE 1 A minimum example GetCapabilities operation request XML encoded for HTTP POST is:

```
<GetCapabilities service="IGS"/>
```

EXAMPLE 2 A larger example GetCapabilities operation request XML encoded for HTTP POST is:

```
<?xml version="1.0" encoding="UTF-8"?>
<GetCapabilities service="IGS">
    <ows:AcceptVersions>
        <ows:Version>0.0.0</ows:Version>
    </ows:AcceptVersions>
    <ows:Sections>
        <ows:Section>All</ows:Section>
    </ows:Sections>
</GetCapabilities>
```

8.2.5 GetCapabilities request SOAP encoding (mandatory)

IGS servers shall implement SOAP version 1.2 transfer of the GetCapabilities operation request as specified in Annex D, using the XML encoding specified above.

EXAMPLE An example GetCapabilities operation request XML encoded for in a SOAP envelope is:

```
<?xml version="1.0" encoding="UTF-8"?>
<env:Envelope>
    <env:Body>
        <GetCapabilities service="IGS">
            <ows:AcceptVersions>
                <ows:Version>0.0.0</ows:Version>
            </ows:AcceptVersions>
            <ows:Sections>
                <ows:Section>All</ows:Section>
            </ows:Sections>
        </GetCapabilities>
    </env:Body>
</env:Envelope>
```

8.3 GetCapabilities operation response

8.3.1 Exceptions

When an IGS server encounters an error while performing a GetCapabilities operation, it shall return an exception report message as specified in Clause 8 of [OGC 06-121r3]. The allowed exception codes shall include those listed in Table 5 of Subclause 7.4.1 of [OGC 06-121r3], except for the the InvalidUpdateSequence exceptionCode when the UpdateSequence parameter is not implemented by a server.

8.3.2 Normal response contents sections

The service metadata document shall contain the four optional sections specified in Table 11. Depending on the values in the Sections parameter of the GetCapabilities operation request, any combination of these sections can be requested and shall be returned when requested.

Table 11 — Section name values and contents

Section name	Contents
ServiceIdentification	Metadata about this specific server. The schema of this section shall be the same as for all OWSs, as specified in Subclause 7.4.3 and owsServiceIdentification.xsd of [OGC 06-121r3].
ServiceProvider	Metadata about the organization operating this server. The schema of this section shall be the same for all OWSs, as specified in Subclause 7.4.4 and owsServiceProvider.xsd of [OGC 06-121r3].
OperationsMetadata	Metadata about the operations specified by this service and implemented by this server, including the URLs for operation requests. The contents and organization of this section shall be the same as for all OWSs, as specified in Subclause 7.4.5 and owsOperationsMetadata.xsd of [OGC 06-121r3].
Contents	Metadata about the data served by this server. For the IGS, this section shall contain data about the coordinate Transformation, GeodeticCRS, and other computational abilities of this server, as specified in Subclauses 8.3.4 and 8.3.5 below.

In addition to these sections, each service metadata document shall include the mandatory "version" parameter specified in Table 6 in Subclause 7.4.1 of [OGC 06-121r3]. The optional updateSequence parameter specified in that table should not be included, as indicated in Table 10.

8.3.3 OperationsMetadata section standard contents

For an IGS, the OperationsMetadata section shall be the same as for all OGC Web Services, as specified in Subclause 7.4.5 and owsOperationsMetadata.xsd of [OGC 06-121r3]. The mandatory values of various (XML) attributes shall be as specified in Table 12. In Table 12, the "Attribute name" column uses dot-separator notation to identify parts of a parent item. The "Attribute value**"** column references an operation parameter, in this case an operation name, and the meaning of including that value is listed in the right column.

Table 12 — Required values of OperationsMetadata section attributes

Attribute name	Attribute value	Meaning of attribute value
Operation.name	Triangulate	The Triangulate operation is implemented by this server.
	GetCapabilities	The GetCapabilities operation is implemented by this server.

In addition to the optional values listed in Table 12, there are many optional values of the "name" attributes and "value" elements in the OperationsMetadata section, which may be included when considered useful. Most of these attributes and elements are for recording the domains of various parameters and quantities.

EXAMPLE The domain of the exceptionCode parameter could record all the codes implemented for each operation by that specific server. Similarly, each of the GetCapabilities operation optional request parameters might have its domain recorded.

For the Triangulate operation, an ows:Parameter element shall be included for each server-specific ControlValue quantity implemented by the server, as specified in Subclause 7.2.1. This ows:Parameter element shall providing the quantity name, meaning, units if any, allowed values, and default value if any. Also, an ows:Parameter element shall be included for all server-specific triangulation results check values implemented, which can be named in the checkPassed and checkFailed elements specified in Table 11 in Subclause 8.2 of [OGC 07-031]. Similarly, an ows:Parameter element shall be included for the "exceptionCode" parameter, which shall list all the exceptionCode values implemented by that server.

All IGS servers shall specify the encodings that may be sent using HTTP POST transfer of operation requests, within the OperationsMetadata section of a service metadata (Capabilities) XML document. Specifically, an ows:Constraint element shall be included, with "PostEncoding" as the value of the "name" attribute and specifying different allowed values for each allowed encoding:

a) The value "SOAP" shall indicate that SOAP encoding is allowed, as specified in Subclause 11.8.

b) The value "XML" shall indicate that XML encoding is allowed (without SOAP message encapsulation).

If the HTTP POST connect point URL is different for different encodings of the operation requests, this ows:Constraint element shall be included in each Post element. If the connect point URL is the same for all encodings of all operation requests, this ows:Constraint element shall be included in the OperationsMetadata element.

8.3.4 Contents section contents

The Contents section for the IGS shall contain data about the coordinate Transformations, GeodeticCRSs, and other computational abilities of this server. The Contents section shall include or reference the data structures shown graphically in the UML diagram in Figure 6 and specified in Table 13.

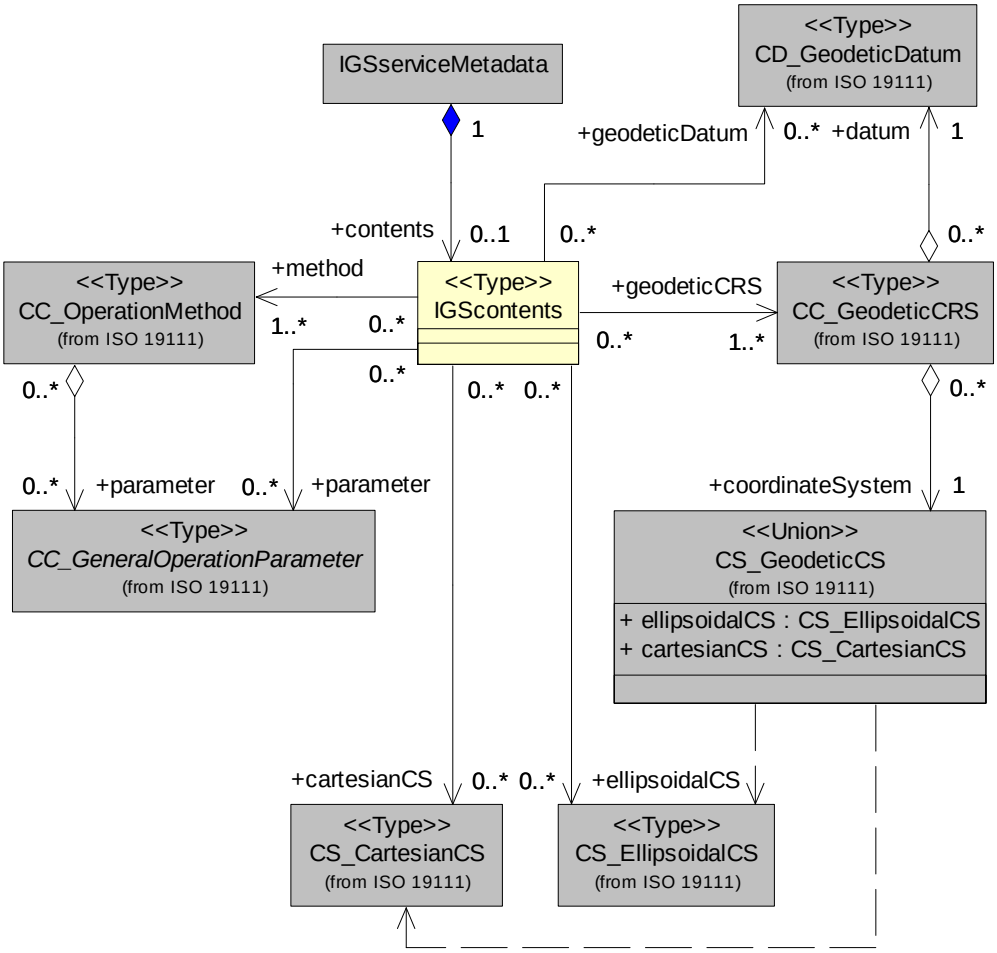

Figure 6 — IGS contents section UML class diagram

Table 13 — Contents of IGS Contents section

Names	Definition	Data type	Multiplicity and use
method method	Association to operation method that this server can use in object-to-image coordinate Transformations	URI or CC_OperationMethod	One or more (mandatory) One for each such operation method implemented by this server
parameter parameter	Association to operation parameter or group that can be used by operation methods	URI or CC_GeneralOperation Parameter	Zero of more (optional) Include when not defined within definition of associated operation methods
geodeticCRS geodeticCRS	Association to geodetic Coordinate Reference System (CRS) that this server can use for object positions and image parameters (TBR)	URI or SC_GeodeticCRS	One or more (mandatory) One for each such CRS implemented by this server
datum datum	Association to geodetic datum that can be used by geodetic CRSs	URI or CD_GeodeticDatum	Zero of more (optional) Include when not defined within definition of associated geodetic CRSs
ellipsoidalCS EllipsoidalCS	Association to ellipsoidal coordinate system that can be used by geodetic CRSs	URI or CS_EllipsoidalCS	Zero of more (optional) Include when not defined within definition of associated geodetic CRSs
cartesianCS CartesianCS	Association to Cartesian coordinate system that can be used by geodetic CRSs	URI or CS_CartesianCS	Zero of more (optional) Include when not defined within definition of associated geodetic CRSs

8.3.5 Implementation requirements

The “Multiplicity and use” columns in Table 6 through Table 16 in [OGC 06-121r3], and in Table 13 of this document, specify the optionality of each listed parameter and data structure in the GetCapabilities operation response. All the “mandatory” parameters and data structures shall be implemented by all OWS servers, using a specified value(s).

All the “optional” parameters and data structures, in the GetCapabilities operation response, should be implemented by all OWS servers using specified values, whenever and wherever each is considered useful metadata for that server.

8.3.6 Capabilities document XML encoding (optional)

A XML schema fragment for an IGS service metadata document extends the ows:CapabilitiesBaseType in owsCommon.xsd of [OGC 06-121r3], and is specified by the XML schema fragment for the Capabilities element in the attached normative XML Schema Document named igsGetCapabilities.xsd.

8.3.7 Capabilities document XML example

In response to GetCapabilities operation request, an IGS server might generate a XML document that looks like:

```
<?xml version="1.0" encoding="UTF-8"?>
<Capabilities version="0.0.0">
    <ows:ServiceIdentification>
        <ows:ServiceType>IGS</ows:ServiceType>
        <ows:ServiceTypeVersion>0.0.0</ows:ServiceTypeVersion>
        <ows:Profile>FrameImage</ows:Profile>
    </ows:ServiceIdentification>
    <ows:ServiceProvider>
        <ows:ProviderName>BAE Systems</ows:ProviderName>
        <ows:ServiceContact>
            <ows:IndividualName>TBD</ows:IndividualName>
            <ows:ContactInfo>
                <ows:Phone>
                    <ows:Voice>TBD</ows:Voice>
                </ows:Phone>
                <ows:OnlineResource xlink:href="TBD"/>
            </ows:ContactInfo>
        </ows:ServiceContact>
    </ows:ServiceProvider>
    <ows:OperationsMetadata>
        <ows:Operation name="Triangulate">
            <ows:DCP>
                <ows:HTTP>
                    <ows:Post xlink:href="TBD">
                        <ows:Constraint name="PostEncoding">
                            <ows:AllowedValues>
                                <ows:Value>SOAP</ows:Value>
                            </ows:AllowedValues>
                        </ows:Constraint>
                    </ows:Post>
                </ows:HTTP>
            </ows:DCP>
        </ows:Operation>
        <ows:Operation name="GetCapabilities">
            <ows:DCP>
                <ows:HTTP>
                    <ows:Get xlink:href="TBD"/>
                </ows:HTTP>
            </ows:DCP>
        </ows:Operation>
    </ows:OperationsMetadata>
    <Contents>
        <method xlink:href="TBD"/>
        <method xlink:href="TBD"/>
        <geodeticCRS xlink:href="TBD"/>
```

```
      <geodeticCRS xlink:href="TBD"/>
   </Contents>
</Capabilities>
```

8.3.8 Capabilities document SOAP encoding (mandatory)

IGS servers that implement SOAP transfer of GetCapabilities operation requests shall also implement SOAP version 1.2 transfer of the GetCapabilities operation response as specified in Annex D, using the XML encoding specified above.

EXAMPLE An example Capabilities document XML encoded for in a SOAP envelope is:

```
<?xml version="1.0" encoding="UTF-8"?>
<env:Envelope>
   <env:Body>
      <Capabilities version="0.0.0">
         <ows:ServiceIdentification>
            <ows:ServiceType>IGS</ows:ServiceType>
            <ows:ServiceTypeVersion>0.0.0</ows:ServiceTypeVersion>
            <ows:Profile>FrameImage</ows:Profile>
         </ows:ServiceIdentification>
         <ows:ServiceProvider>
            <ows:ProviderName>BAE Systems</ows:ProviderName>
            <ows:ServiceContact>
               <ows:IndividualName>TBD</ows:IndividualName>
               <ows:ContactInfo>
                  <ows:Phone>
                     <ows:Voice>TBD</ows:Voice>
                  </ows:Phone>
                  <ows:OnlineResource xlink:href="TBD"/>
               </ows:ContactInfo>
            </ows:ServiceContact>
         </ows:ServiceProvider>
         <ows:OperationsMetadata>
            <ows:Operation name="Triangulate">
               <ows:DCP>
                  <ows:HTTP>
                     <ows:Post xlink:href="TBD">
                        <ows:Constraint name="PostEncoding">
                           <ows:AllowedValues>
                              <ows:Value>SOAP</ows:Value>
                           </ows:AllowedValues>
                        </ows:Constraint>
                     </ows:Post>
                  </ows:HTTP>
               </ows:DCP>
            </ows:Operation>
            <ows:Operation name="GetCapabilities">
               <ows:DCP>
                  <ows:HTTP>
                     <ows:Get xlink:href="TBD"/>
                  </ows:HTTP>
               </ows:DCP>
            </ows:Operation>
         </ows:OperationsMetadata>
         <Contents>
            <method xlink:href="TBD"/>
            <method xlink:href="TBD"/>
```

```
            <geodeticCRS xlink:href="TBD"/>
            <geodeticCRS xlink:href="TBD"/>
         </Contents>
      </Capabilities>
   </env:Body>
</env:Envelope>
```

Annex A
(normative)

Abstract test suite

An abstract test suite is not provided in this version of this Implementation Specification, but should be included in version 1.0.0.

Annex B
(normative)

XML Schema Documents

In addition to this document, this specification includes normative XML Schema Documents. These XML Schema Documents are bundled in a zip file with the present document. After OGC acceptance of a Version 1.0.0 of this specification, these XML Schema Documents will also be posted online at the URL http://schemas.opengeospatial.net/igs/1.0.0. In the event of a discrepancy between the bundled and online versions of the XML Schema Documents, the online files shall be considered authoritative.

The IGS abilities now specified in this document use three specified XML Schema Documents included in the zip file with this document. These XML Schema Documents combine the XML schema fragments listed in various subclauses of this document. Two of these XML Schema Documents roughly match the two UML packages described in Annex C. These three XML Schema Documents are named:

igsTriangulate.xsd

igsGetCapabilities.xsd

igsAll.xsd

These XML Schema Documents use and build on the OWS Common version 1.1 XML Schema Documents specified in [OGC 06-121r3], also included in the zip file with this document and named:

ows19115subset.xsd

owsCommon.xsd

owsDataIdentification.xsd

owsExceptionReport.xsd

owsGetCapabilities.xsd

owsOperationsMetadata.xsd

owsServiceIdentification.xsd

owsServiceProvider.xsd

These XML Schema Documents also use and build on the Image Geopositioning Metadata GML 3.2 Application Schema specified in [OGC 07-031].

All these XML Schema Documents contain documentation of the meaning of each element and attribute, and this documentation shall be considered normative as specified in Subclause 11.6.3 of [OGC 06-121r3].

Annex C
(informative)

UML model

C.1 Introduction

This annex provides a UML model of the IGS interface, using the OGC/ISO profile of UML summarized in Subclause 5.3 of [06-121r3].

Figure C.1 is a simple UML diagram summarizing the IGS interface. This class diagram shows that the ImageGeopositioningService class inherits the getCapabilities operation from the OGCWebService interface class, and adds the triangulate operation. (The capitalization of names uses the OGC/ISO profile of UML.)

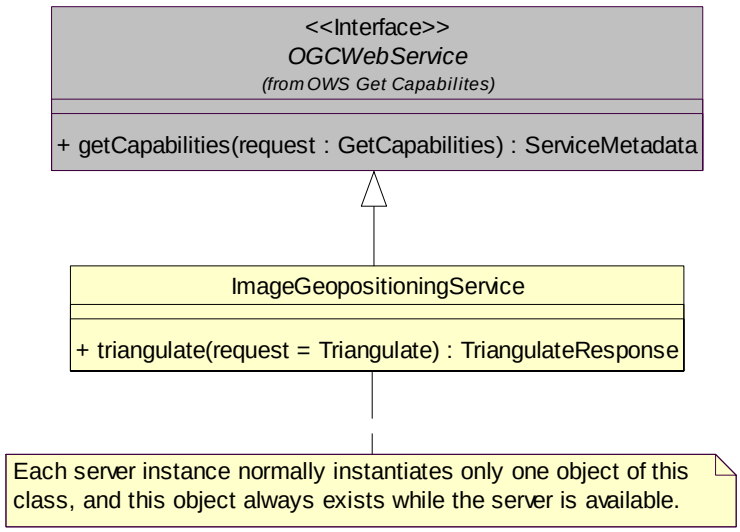

Figure C.1 — IGS interface UML diagram

Each of the two operations uses a request and a response data type, each of which is defined by one or more additional UML classes. The following subclauses provide a more complete UML model of the IGS interface, adding UML classes defining the operation request and response data types.

C.2 UML packages

The IGS interface UML model is organized in three packages, as shown in the package diagram in Figure C.2. This package diagram shows the dependencies among the various packages shown. The IGS-specific packages make direct use of five OWS Common packages, named OWS Get Capabilities, OWS Service Identification, OWS Service Provider, and OWS Operations Metadata. These IGS-specific packages also make direct use of several classes from the ISO 19111 UML model, as listed.

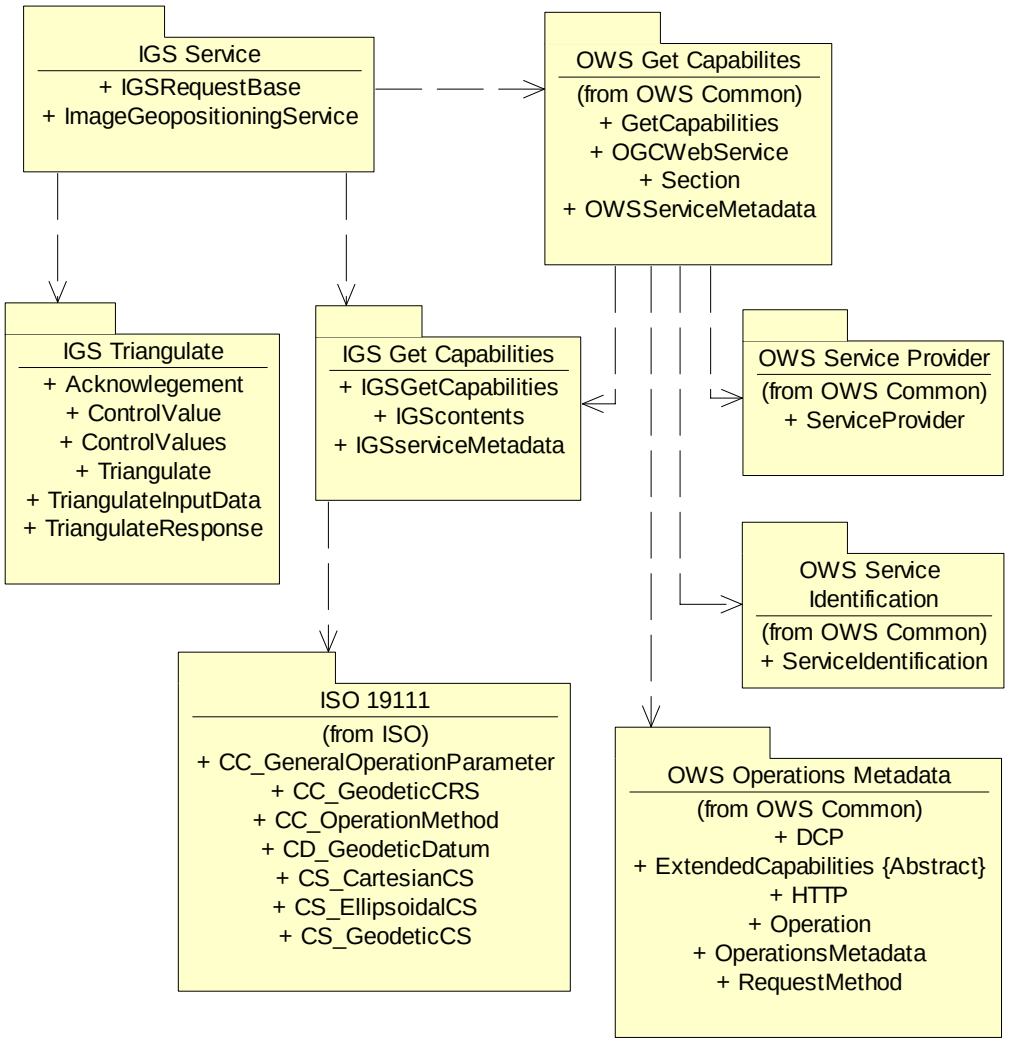

Figure C.2 — IGS interface package diagram

Each of the three IGS-specific packages shown in Figure C.2 is described in the following subclauses. The OWS Get Capabilities, OWS Service Identification, OWS Service Provider, OWS Operations Metadata, and OWS Input Output Data packages are described in Annex C of [OGC 06-121r3].

C.3 Image Geopositioning Service package

The Image Geopositioning Service package is shown in the class diagram in Figure C.3. This diagram does not show the classes used by the two operation requests and responses, which are shown (with part of this package) in the Triangulate and the IGS Get Capabilities packages. This diagram also shows two used classes from the OWS Web Service package, which is common to all OGC Web Services.

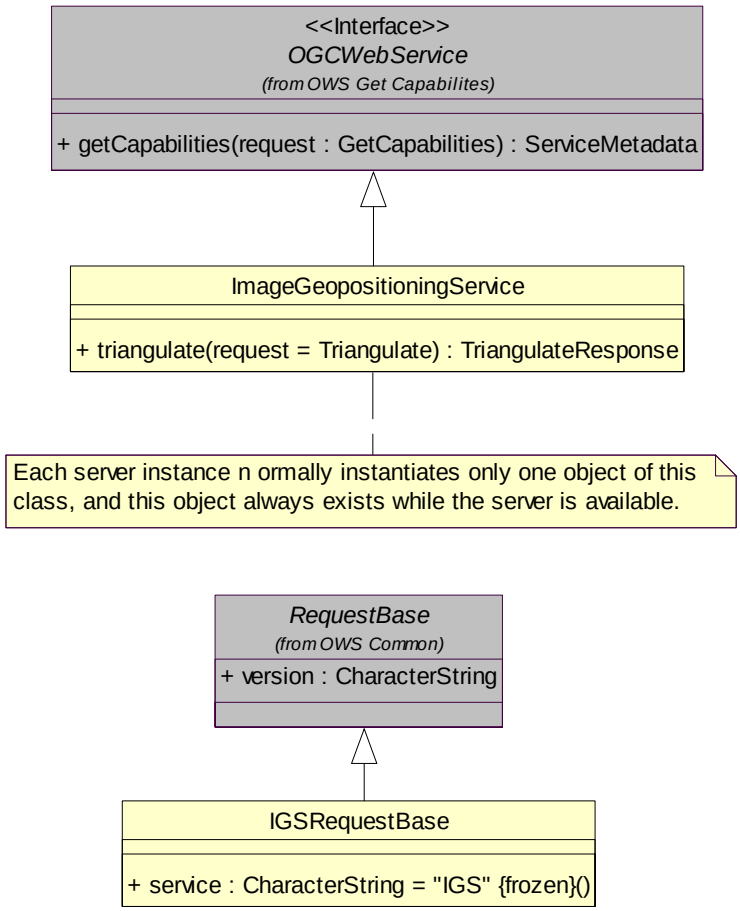

Figure C.3 — Image Geopositioning Service package class diagram

C.4 Triangulate package

The Triangulate package is shown in the class diagram in Figure C.4 through C.6. This diagram also shows two classes each from the IGS Service and OWS Get Capabilities packages. The four classes introduced by this package are further defined by Table 2 through Table 4 and Table 6 in this document.

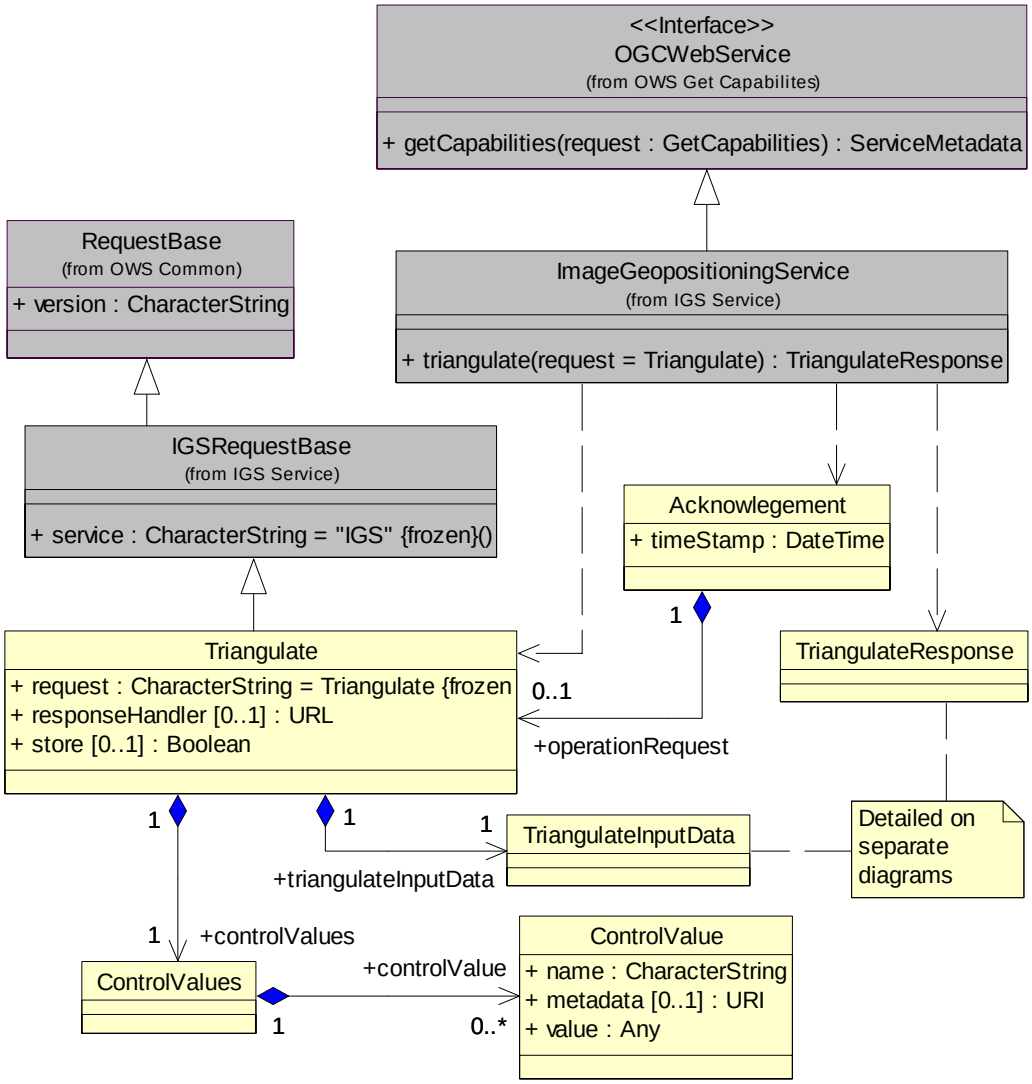

Figure C.4 — Triangulate package class diagram, part 1

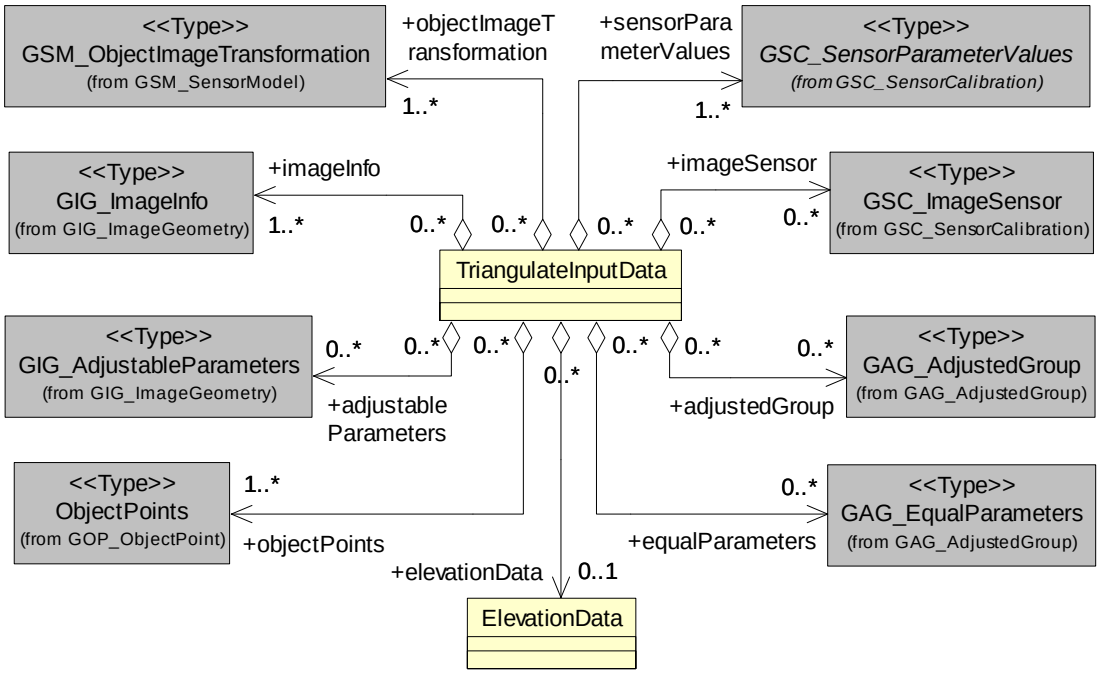

Figure C.5 — Triangulate package class diagram, part 2

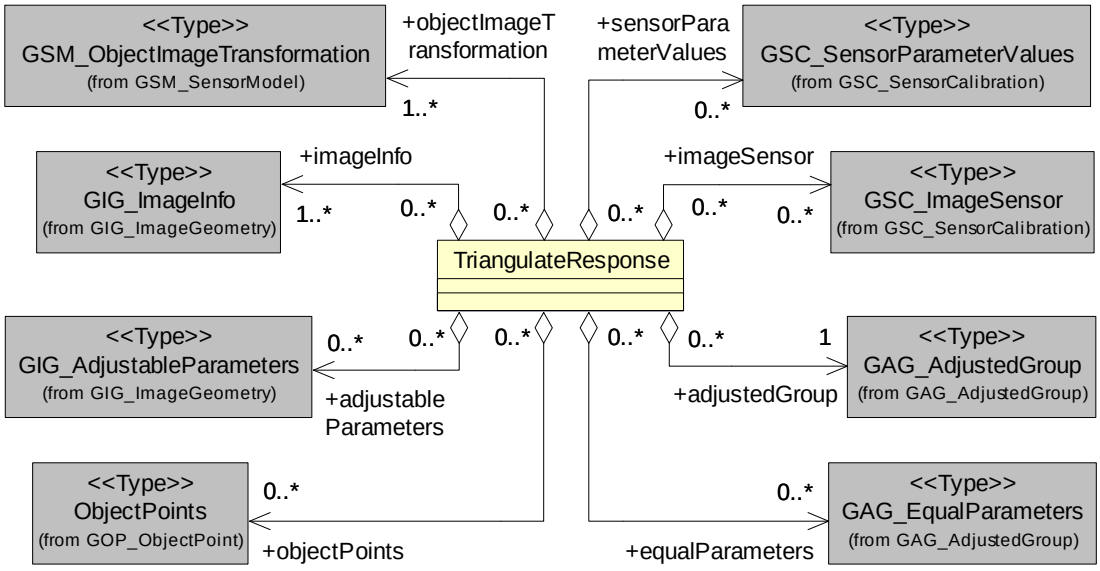

Figure C.6 — Triangulate package class diagram, part 3

C.5 IGS Get Capabilities package

The IGS Get Capabilities package is shown in the class diagram in Figure C.7 and Figure C.8. This diagram also shows seven classes from OWS Common packages, plus two classes from ISO 19111 [OGC 05-103]. The new classes in this package are further defined by Table 11 through Table 13 in this document.

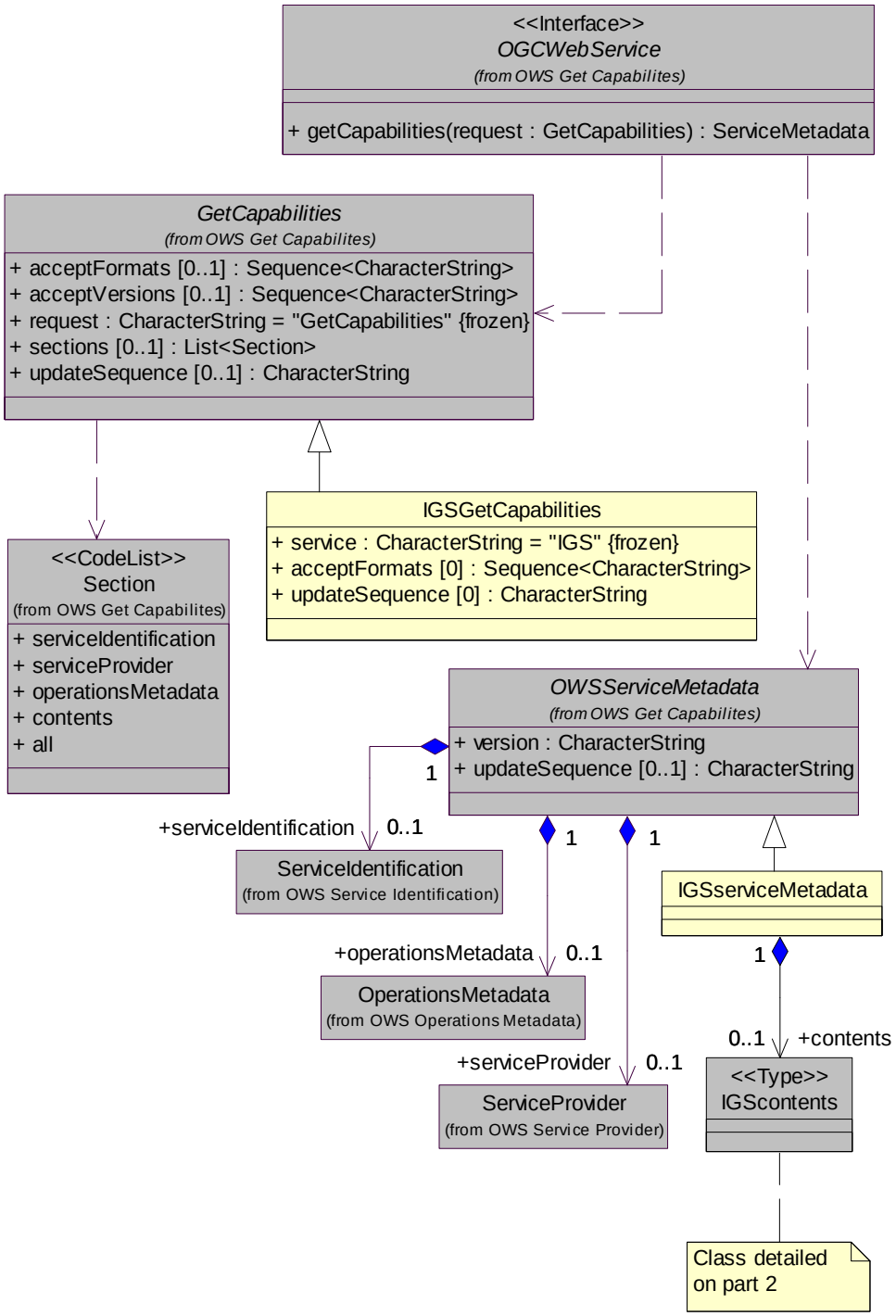

Figure C.7 — IGS Get Capabilities package class diagram part 1

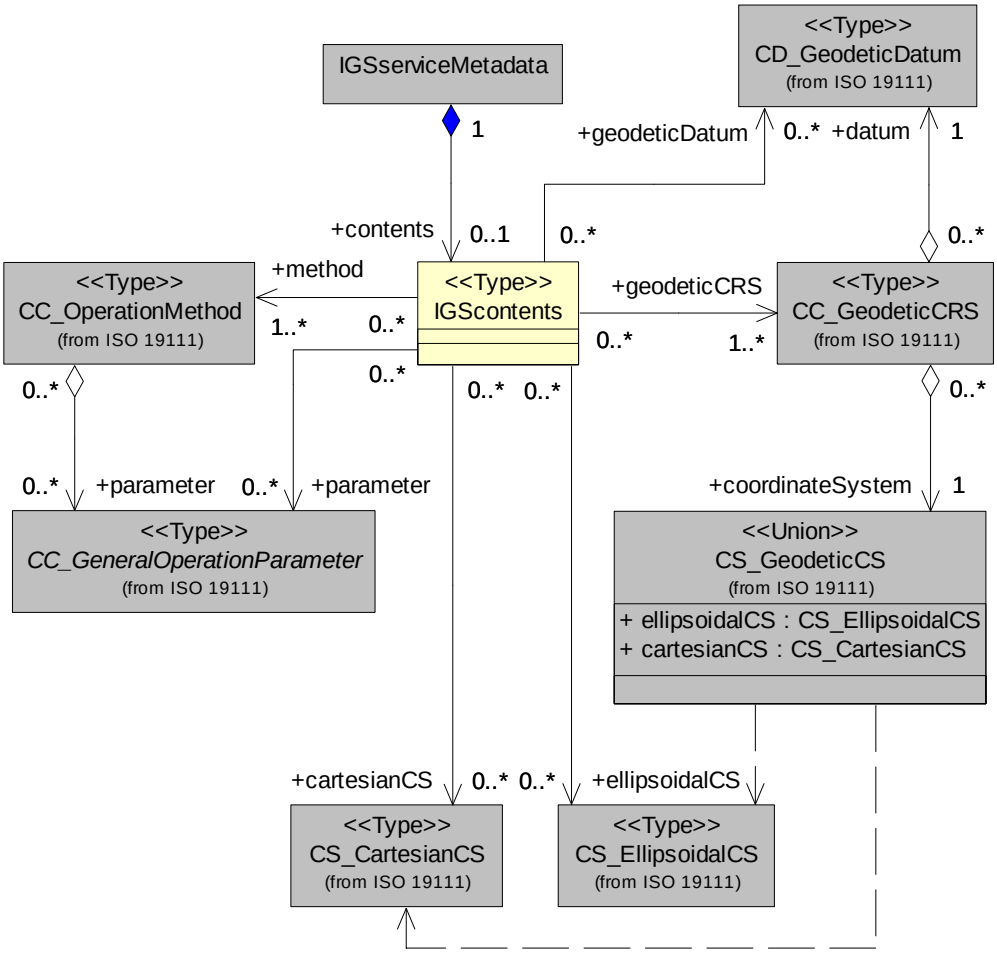

Figure C.8 — IGS Get Capabilities package class diagram part 2

Annex D
(normative)

SOAP transfer

All compliant IGS servers shall implement SOAP 1.2 transfer of all IGS operation requests and responses, using the XML encodings specified in the body of this document. The SOAP Request-Response message exchange pattern shall be used with the HTTP POST binding.

For SOAP transfer, each XML-encoded operation request shall be encapsulated in the body of a SOAP envelope, which shall contain only a body and only this request in that body. Similarly, each XML-encoded operation response shall be encapsulated in the body of a SOAP envelope, which shall contain only a body and only this response in that body. An IGS server shall return operation responses and error messages using only SOAP transfer when the operation request is sent using SOAP.

All compliant IGS servers shall specify the URLs to which SOAP-encoded operation requests shall be sent, within the OperationsMetadata section of a service metadata (Capabilities) XML document, as specified in Subclause 8.3.3.

If an error is detected while processing an operation request encoded in a SOAP envelope, the IGS server shall generate a SOAP response message where the content of the Body element is a Fault element containing an ExceptionReport element. This shall be done using the following XML fragment:

```
<soap:Envelope xmlns:soap=http://www.w3.org/2003/05/soap-envelope>
   <soap:Body>
      <soap:Fault>
         <soap:Code>
            <soap:Value>soap:Server</soap:Value>
         </soap:Code>
         <soap:Reason>
            <soap:Text>A server exception was encountered.<soap:Text>
         </soap:Reason>
         <soap:Detail>
            <ows:ExceptionReport>
               ...
            </ows:ExceptionReport>
         </soap:Detail>
      </soap:Fault>
   </soap:Body>
</soap:Envelope>
```

The Code element shall have the Value “soap:server” indicating that this is a server exception. The Reason element shall have the Text “Server exception was encountered.” This fixed string is used since the details of the exception shall be specified in the Detail element using an ows:ExceptionReport element as specified in OWS Common [OGC 06-121r3].

Bibliography

[1] ASPRS 2004, Manual of Photogrammetry, Fifth Edition, American Society for Photogrammetry and Remote Sensing, 2004

[2] ISO 19105:2000, Geographic information — Conformance and Testing

[3] ISO/TS 19138 draft n1934, Geographic information — Data quality measures

[4] OGC 00-115, OGC Abstract Specification Topic 15: Image Exploitation Services

[5] OGC 04-052, OWS 1.2 image handling requirements

[6] OGC 05-094r1, GML 3.1.1 CRS support profile

[7] OGC 05-095r1, GML 3.1.1 common CRSs profile, available at

[8] OGC 05-096r1, GML 3.1.1 grid CRSs profile, available at

