DGIWG 124

Defence Profile of OGC's Web Map Tile Service 1.0

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Abstract:	This document is a profile of OGC 07-057r7, v.1.0.0, dated 2010-04-06. It defines specific Defence requirements, recommendations and guidelines for implementations of a Web Map Tile Service.
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Executive Summary

This document defines specific DGIWG requirements, recommendations and guidelines for implementations of a Web Map Tile Service (WMTS) based on the Open Geospatial Consortium (OGC) OpenGIS® Web Map Tile Service Implementation Standard version 1.0.0. As an Interoperability Standard, it provides detailed direction on how to use the clauses, options, and parameters of the base standard(s). This guidance is designed to be specific enough for any two independent and compliant software implementations to 'plug and play' with each other.

The OGC WMTS specification was developed to improve the performance of a Web Map Service by enabling pre-cached tiles at defined set scales.

The framework, concepts, and methodology for testing, and the criteria to be achieved to claim conformance to the underlying OGC WMTS specification are summarised in the OGC Compliance Testing Policies and Procedures on the OGC Compliance Testing web site[1].

To ensure the ability of implementing this profile, existing constraints among submitting organizations and vendors have been taken into account, in order to distinguish between requirements, recommendations and future work directions. Requirements include both extensions/restrictions of the WMTS base standard and system requirements in order to enable interoperability by appropriate configuration of existing software. System requirements are intended to be applied in the design of systems requiring services compliant to this profile. Requirements are associated with conformance tests which provide guidelines for testing the compliance of implementations.

The WMTS interface offers 3 Operations:

- GetCapabilities (mandatory): Allows for obtaining Service Metadata
- GetTile (mandatory): Returns a map tile
- GetFeatureInfo (optional): Provides additional information about features in the pictures of maps that were returned by previous GetTile requests

A DGIWG Server Software implementation that claims to be conformant with the DGIWG WMTS **SHALL** support **all mandatory operations, paramiters**, and **elements** of the this standard as defined in this document.

The DGIWG WMTS profile **references** the different **operations** and **parameters** of the base **OGC WMTS** standard and subsequently defines specific **DGIWG requirements** and **recommendations** for software implimentations to foster interoperability and use in the military domain.

[1] www.opengeospatial.org/cite

i. Submitting organizations

For the Defence Geospatial Information Working Group (DGIWG):

Nation	**Parent organizations**
France	Institut Géographique National (IGN)
Germany	Bundeswehr Geoinformation Centre (BGIC)
United Kingdom	Defence Science and Technology Laboratory (DSTL) Joint Forces Intelligence Group (JFIG)
United States	National Geospatial-Intelligence Agency (NGA)

ii. Contributing participants

Note: Due to the complexity of this document, it was necessary to seek the guidance of individual agencies to reach out to a wider community.

Nation	**Parent organizations**
France	Institut Géographique National (IGN)
Germany	Bundeswehr Geoinformation Centre (BGIC)
United Kingdom	Defence Science and Technology Laboratory (DSTL) Joint Forces Intelligence Group (JFIG)
United States	National Geospatial-Intelligence Agency (NGA)
New Zealand	New Zealand Defence Force (NZDF)
NATO	Joint Warfare Centre

1. Introduction

This document defines specific DGIWG requirements, recommendations and guidelines for implementations of the OGC Web Map Tiled Service (WMTS) standard which is based on the OGC Web Map Tile Service Implementation Specification (document number OGC 07-057r7), version 1.0.0, dated 2010-04-06. This profile should be followed in its entirety to enable interoperability in a coalition environment.

The goal of providing a WMTS enabled service is to be performance oriented and scalable. Therefore, servers must be able to return tiles quickly. A good way to achieve this is to use locally stored pre-rendered tiles that will not require any image manipulation or geo-processing. Server developers will decide if pre-rendered tiles will be generated in a previous tile-preparation process or generated on the fly utilizing a caching mechanism. With tile-based mapping it is important that the server will be able to handle asynchronous access to tiles as most clients will simultaneously query for multiple tiles to fill a single view.

The purpose of a WMTS service is to serve maps divided in individual tiles. The WMTS interface allows a client to receive three types of resources either in response to a resource request in the resource oriented architectural style or in response to an operation in the procedure oriented architectural style. Those resources and operations are:

- **GetCapabilities** (mandatory): Allows for obtaining Service Metadata
- **GetTile**(mandatory): Returns a map tile
- **GetFeatureInfo** (optional): Provides additional information about features in the pictures of maps that were returned by previous GetTile requests

The WMTS Implementation Specification defines two conformance classes, “Basic WMTS” and “Queryable WMTS”. The Basic WMTS supports the mandatory GetCapabilities and GetTile operations (requests and responses) whereas the Queryable WMTS supports all Basic WMTS operations and the GetFeatureInfo operation. The DGIWG WMTS profile mandates the implementation of the Basic WMTS.

Software implementations that claim to be conformant with the DGIWG WMTS profile SHALLsupport the OGC WMTS 1.0 specification, as per normative reference [1] of this document.

The DGIWG WMTS profile is written in such a way that it references the different operations and parameters of the base standard and then defines specific requirements for software implementation.

2. Scope

A traditional Web Map Service (WMS) creates maps dynamically based on the end users area of interest. However, the dynamic nature of these services can often slow performance especially in low bandwidth environments. The Open Geospatial Consortium Web Map Tile Service (OGC WMTS) specification was developed to improve this performance by enabling pre-cached tiles at set scales to be called by the system when required. To enable the full effect of this performance WMTS services require large volumes of data to be pre-cached at set scale bands. However, if the end user wishes to display services using different projections or scales, then the provider either has to generate a new cache or the system has to convert the data on the fly. To minimise the burden on the data manager or system it is important that a single projection and scale set is decided upon. This may create a number of problems which are summarised below:

Projection:

Traditionally geospatially enabled systems have utilised unprojected geographically referenced data as it is processed. However, this produces an asymmetric distortation which increases towards the poles; resulting in positional inaccuracies. To improve the end user experience the web based commercial sector developed the Web Mercator projection, which is a simplified form of the Mercator projection. Both the Mercator and Web Mercator projections provide an improved user experience by replacing the asymmetric distortion by a symmetric distortion towards the poles. In simplifying the mathematical equations, the Web Mercator projection introduced additional small distortions (no more than 0.5%) because it does not preserve the linear scale. Because of this, this projection is not suitable for use cases that require accuracy such as navigation or targeting. The Mercator projection provides the best near-global view, but is not suitable for polar regions, where the Universal Polar Stereographic projection is best suited.

Well Known Scale Sets (WKSS):

WKSS are the predefined scale bands utilised by GIS services and systems to improve performance by only displaying the data relevant to the scale being viewed. The WMTS service utilises these WKSS to display tiled data. However, often geospatial systems are unable to perform the complex calculations required to display tiled data using different WKSS. This means that the systems are unable to display tiled data created using different scales on screen at the same time. To avoid this problem, it is important to agree on a common combination of a coordinate reference system and a set of scales for a tile matrix set. By providing data based on agreed WKSS, clients can easily overlay WMTS tiles from different services.

The issues summarised above make it essential to agree projection and WKSS to make sharing tiled raster data and interoperability in a coalition environment possible, as the OGC WMTS specification does provide not sufficient guidance. DGIWG has created this profile to provide additional clarity and guidance for implementing the OGC WMTS specification to enable interoperability in the coalition environment. However, this profile also recognises that organisations may need to utilise different configurations of the WMTS such as different projections or WKSS to meet specific operational requirements.

The following table summarises the various use cases for this profile.

Table 1: Use Cases

ID	Name	Use case	How to use DGIWG Profile
Use Case 1	National \Organisational	An organisation has a specific operational requirement to use a WMTS to disseminate tiled raster data using a local projection and WKSS.	This profile SHALL be used as guidance for implementing a WMTS. In this instance the profile should be followed and only changed to meet operational requirements.
Use case 2	Coalition	Operations where a WMTS is required to share tiled raster data with coalition partners.	This profile SHALL be followed in its entirety.

3. Conformance

3.1 Conformance classes

This document establishes two conformance classes:

- DGIWG Basic WMTS
- DGIWG Queryable WMTS, which extends the DGIWG Basic WMTS.

Annex A lists the conformance abstract tests which shall be exercised on any software artefact claiming to implement a DGIWG WMTS profile.

DGIWG WMTS Profile conformance class defines requirements for WMTS servers allowing distribution of geographic data in a military environment.

Table 2: DGIWG WMTS Profile conformance class in a military environment

Conformance class name	Operation or behavior	OGC WMTS Conformance Test	DGIWG WMTS Conformance Test
OGC WMTS	The server shall implement the DGIWG Basic WMTS conformance class DGIWG Requirement Requirement 1 to Requirement 14	**A.2 Basic WMTS**	
DGIWG Basic WMTS (URI) http://www.dgiwg.org/std/wmts/1.0/conf/basic	**DGIWG requirements** **DGIWG Basic WMTS Profile (normative)** Requirement 1 to Requirement 14		A.2 Server test Module (DGIWG Basic WMTS)
DGIWG Queryable WMTS (URI) http://www.dgiwg.org/std/wmts/1.0/conf/queryable	**DGIWG requirements** DGIWG Queryable WMTS (normative) All requirements from DGIWG Basic WMTS and Requirement 15 to Requirement 19		A.3 Server test Module (Queryable DGIWG WMTS)

4. Normative and informative References

4.1 Normative References

Normative references in this standard are identified in Table 1.

Table 3: Normative References in WMTS interoperability Standard

ID	Standard or Specification	Description of Service
1	OpenGIS® Web Map Tile Service Implementation Standard, Version: 1.0.0, Reference number of this document: OGC 07-057r7, Date: 2010-04-06	A WMTS enabled server application can serve map tiles of spatially referenced data using tile images with predefined content, extent, and resolution.

4.2 Informative References

The documents listed in Table 4 contain useful information to augment understanding and application of the material in this interoperability standard in conjunction with the actual standard profiled.

Table 4: Informative References in the DGIWG WMTS Interoperability Standard

Reference ID	Standards and Specifications Title	Version
OGC 13-082r2, February 19th, 2016	OGC WMTS Simple Profile	NA
OGC Project Document 08-038r5, March 7th, 2017	Draft Revision to Axis Order Policy and Recommendations	NA
Implementing INSPIREView Services Version 3.0 21/03/2011: Section 5	Technical Guidance for the Implementation of INSPIRE View Services Version 3.0	3.0
ISO 19106:2004(E)	Geographic information — Profiles	1
IETF RFC 2119, S. Bradner, Harvard University, March 1997	Key Words for use in RFCs to Indicate Requirement Levels	1
OGC 03-040, v0.1.3, September 16th, 2003	OpenGIS® Reference Model	1.3
OGC 06-004r3, v1.0.0, February 28th, 2006	Geospatial Digital Rights Management Reference Model (GeoDRM RM)	1.0
NGA.STND.0020_5.0	National System for Geospatial-Intelligence (NSG) Feature Data Dictionary (NFDD), Version 5.0, 1 October 2012	5.0
NGA.STND.0021_5.0	National System for Geospatial-Intelligence (NSG) Entity Catalog (NEC), Version 5.0, 1 October 2012	5.0

Reference ID	Standards and Specifications Title	Version
NGA.STND.0022_5.0	National System for Geospatial-Intelligence (NSG) Application Schema (NAS) – Part 1: Platform Independent Model, Version 5.0, 1 October 2012	5.0
NGA.STND.0012_2.1	National System for Geospatial Intelligence Metadata Foundation (NMF) – Part 1: Conceptual Schema Profile, Version 2.1, 26 March 2012	2.1
NGA.STND.0018_2.1	National System for Geospatial Intelligence Metadata Implementation Specification (NMIS) – Part 2: XML Exchange Schema, Version 2.1, 31 October 2012	2.1
NGA.SIG.001_1.0.0_WEBMERC 2014-02-18	National Geospatial-Intelligence Agency (NGA) Standardization Document Implementation Practice - Map Projections for Tiled Raster Graphics, 24 April 2015	1.0
NGA.SIG.0014_1.0_PROJRAS Mercator-Addendum	National Geospatial-Intelligence Agency (NGA) Standardization Document Implementation Practice - Map Projections for Tiled Raster Graphics - Addendum for the Mercator Projection, 17 May 2016	1.0
NGA.SIG.0014_1.0_PROJRAS UPS-Amendment	National Geospatial-Intelligence Agency (NGA) Standardization Document Implementation Practice - Map Projections for Tiled Raster Graphics - Amendment for Universal Polar Stereographic, 3 June 2016	1.0
OGC Web Service Common Implementation Specification, Version 2.0.0, OGC 06-121r9, Date: 2010-04-07	Specifies many of the aspects that are, or should be, common to all or multiple OGC Web Service (OWS) interface Implementation Standards.	2.0
DGIWG 114	DGIWG Metadata Foundation Version 2.0	2.0
NGA.STND.0022_6.1 2014-09-02	National System for Geospatial Intelligence Application Schema (NAS) – Part 1: Platform Independent Model	2.0
Implementation Practice Web Mercator Map Projection	GML Simple Features Profile that specifies restricted subset of simple geometry types.	
W3C SOAP Version 1.2 Part 1	W3C SOAP Version 1.2 Part 1: Messaging Framework, W3C Recommendation, Date 2003-06-24	1.2
W3C SOAP 1.2 Attachment Feature	W3C SOAP 1.2 Attachment Feature, W3C Working Group Note, Date 2004-06-08	1.2

NOTE: Implementers of the DGIWG WMTS 1.0 Profile should verify all Reference documents for latest edition against the holdings found under http://www.dgiwg.org/dgiwg/htm/documents/documents.htm; Open Geospatial Consortium (OGC) documents are located at http://www.opengeospatial.org/standards and the NSG Standards Registry of Documents. References in Table 4 correct as of DGIWG WMTS 1.0 Profile date.

5. Terms, Definitions and abbreviations

5.1 Terms and Definitions

For the purposes of this document, terms and definitions found in **OGC 09-025r1** apply.

URIs given in this document for each requirement or conformance test URIs are relative paths to be appended to the root http://www.dgiwg.org/std/wmts/1.0/conf/basic

5.2 Abbreviations

Abbreviation associated with this document only.

CRS	Coordinate Reference System
DGIWG	Defence Geospatrial Information Working Group
EPSG	European Petroleum Survey Group
GIS	Geographic Information System
GML	Geographic Markup Language
HTTP	HyperText Markup Language
IC	Intelligence Community
ISO	International Organization for Standardization
JPEG	Joint Photographic Experts Group
KVP	Key-Value Pair
NAS	NSG Application Schema
NATO	North Atlantic Treaty Organisation
NFDD	NSG Feature Data Dictionary
NSG	National System for Geospatial-Intelligence
OGC	Open Geospatial Consortium
OWS	OGC Web Services
PNG	Portable Network Graphics (Image Format)
REST	Representational State Transfer
SLD	Styled Layer Descriptor
SOAP	Simple Object Access Protocol
TC	Technical Committee
UML	Unified Modelling Language
UPS	Universal Polar Stereographic
URL	Uniform Resource Locator
WGS 84	World Geodetic System 1984
WKSS	Well Known Scale Sets
WMS	Web Map Service
WMTS	Web Map Tile Service
XML	Extensible Markup Language

6. Introduction

A WMTS that complies with this standard SHALL

a) satisfy all requirements stipulated in the OGC WMTS 1.0.0 Specification;

b) satisfy all requirements stipulated in this document.

This profile provides advice on the implementation of the WMTS so that tests can be provided to ensure objective compliance to the profile. The profile provides a “Normative Clause” to describe how each component shall be implemented. The Normative Clause defines requirements where mandatory compliance is required for attainment of conformance. However, the profile also includes optional recommendations that may require a subjective test.

The following syntax is used to indicate the compliance requirement within the profile:

- **Mandatory** (**M**) – The requirement shall be implemented
- **Conditional** (**C**) – Mandatory when “If” statement applies
- **Optional** (**O**) – Should be implemented

Note: All Requirements and Recommendations presented within this document are the result of information gathered during the DGIWG Nations questionnaire/survey process.

7. DGIWG Basic WMTS Profile

7.1 Normative Requirements

The Normative requirements (mandatory) for a WMTS 1.0 Basic server implementation as required by this profile are summarized in Table 5. Numbering is sequential and linked to the specific Requirement number as defined within this document.

Table 5: DGIWG Basic WMTS Profile Normative Requirements

No.	Category	Modifier	DGIWG Requirement	Compliance
1	Service Type	N/A	A DGIWG Basic WMTS server SHALL be compliant to the Basic WMTS conformance class	M
2	Architectural Patterns/ Encoding	N/A	A DGIWG WMTS server SHALL support REST architectural patterns/encoding techniques	M
3	GetCapabilities	KVP	A DGIWG WMTS server SHALL declare its support for GetCapabilities operations using KVP with HTTP GET by providing an OperationsMetadata section in the ServiceMetadata document with an Operation section for each supported HTTP request type.	M
4		REST	A DGIWG WMTS server SHALL generate a ServiceMetadata document in response to a GetResourceRepresentation request in REST architecture that looks like the one described in section 7.1.1.3 of Normative Reference 1.	M
5	GetTile	KVP	A DGIWG WMTS server SHALL support KVP encoding of the GetTile operation request using parameters specified in [Normative Reference 1, Table 29 (GetTile operation request URL parameters)].	M
6		REST	A DGIWG WMTS server SHALL provide standard endpoints from which a representation of each tile resource can be obtained.	M
7	Coordinate Reference systems	N/A	A DGIWG WMTS server SHALL be capable of providing tiles in the following coordinate reference systems: • CRS:84 WGS84 geographic longitude, then latitude, expressed in decimal degrees	M

No.	Category	Modifier	DGIWG Requirement	Compliance
			• EPSG: 4326 WGS84 geographic latitude, then longitude, expressed in decimal degrees	
8	Projections	N/A	A DGIWG WMTS server SHALL comply with one or more of the following projections: World Mercator EPSG: 3395 Universal Polar Stereographic North EPSG: 5041 Universal Polar Stereographic South EPSG: 5042	M
9	Well-Known Scale Sets	N/A	DGIWG WMTS server SHALL employ the Well-Known Scale Sets as appropriate for the CRS/Projection chosen (see Annex B)	M
10	Tile Formats	N/A	A DGIWG WMTS server SHALL be capable of offering tiles in the following formats: image/png, image/jpeg, and image/gif file formats.	M
11	Negotiation of Standard Version	N/A	A DGIWG WMTS server SHALL support negotiation of the standard version used for client-server interactions (procedure oriented architectural style).	M
12	Key Word List	N/A	A DGIWG WMTS server SHALL have a minimum keyword list based on the Defence Geospatial Information Framework -2 (DGIF-2) Groupings	M
13	Metadata	N/A	A DGIWG WMTS server SHALL provide all service metadata elements based upon the DGIWG Metadata Foundation (DMF) v2.0.	M
14	Cacheable Resources	N/A	A DGIWG WMTS server SHALL provide the “tile expiration date” as part of the data caching information.	M

7.2 Non-Normative Recommendations for Implementation

The non-normative requirements requested by this profile are summarized in Table 6

Table 6: DGIWG WMTS Profile Non-normative Recommendations

No.	Category	Modifier	Recommendation	Compliance
1	SOAP Encodings	N/A	A DGIWG WMTS server should support SOAP encodings, if required.	O
2	MIME Type	N/A	If a service requires feature coordinate information, it is recommended that FeatureInfo documents be offered in the MIME type format “application/gml+xml; version=3.2”.	O
3	Order of Variables and Values in URL Template	N/A	Any possible order of the variables and values in the URL template is valid. Nevertheless, recommend the following order: style, firstDimension, ..., lastDimension, TileMatrixSet, TileMatrix, TileRow, TileCol, J and I.	O
4	Themes	N/A	It is recommended that the themes section of a WMTS service metadata document contain data about how layers are organized thematically. [Normative Reference 1, P.28]	O

7.3 Service Structure

The goal of providing a WMTS enabled service is to be performance oriented and scalable. Therefore, servers must be able to return tiles quickly. A good way to achieve this is to use locally stored pre-rendered tiles that will not require any image manipulation or geo-processing. Server developers will decide if pre-rendered tiles will be generated in a previous tile-preparation process or generated on the fly utilizing a caching mechanism. With tile-based mapping it is important that the server will be able to handle asynchronous access to tiles as most clients will simultaneously query for multiple tiles to fill a single view. The purpose of a WMTS service is to serve maps divided in individual tiles.

The WMTS interface allows a client to receive three types of resources either in response to a resource request in the resource oriented architectural style or in response to an operation in the procedure oriented architectural style. Those resources and operations are:

a) A **ServiceMetadata** resource (in response to a GetCapabilities operation for the procedure oriented architectural style) (required implementation by servers) – It describes the abilities and information holdings of the specific server implementation. In procedure oriented architectural style this operation also supports negotiation of the standard version being used for client-server interactions.

b) A **tile** resource (in response to a GetTile operation for the procedure oriented architectural style) (required implementation by servers) – It shows a fragment of a map representation of a layer.

c) A **FeatureInfo** resource (in response to a GetFeatureInfo operation for the procedure oriented architectural style) (required implementation by servers) – It provides information about the features located at a particular pixel of a tile map, in a similar way to the WMTS GetFeatureInfo operation, by providing, for example, the thematic attribute name and value pairs in textual form

7.4 Service Type

This stnadard defines two conformance classes, “Basic WMTS” and “Queryable WMTS”. A Basic WMTS supports the GetCapabilities and GetTile operations (requests and responses); a Queryable WMTS includes all Basic WMTS operations and an additional GetFeatureInfo operation.

Requirement 1: A DGIWG Basic WMTS server SHALL be compliant to the Basic WMTS conformance class.

According to this requirement a DGIWG WMTS server shall support the GetCapabilities and GetTile operations. This requirement ensures compatibility with the base standard.

7.5 Architectural Styles

OGC’s WMTS Implementation Standard defines a standardized approach to declaring the images which a client can request from a server, enabling a single type of client to be developed for all servers. The standard specifies two different architectural styles, a procedure oriented architectural style and a resource oriented architectural style. For the former architectural style, there are several exchange mechanisms between clients and servers identified, including messages encoded using KVP, XML messages, or XML messages embedded in SOAP envelopes. The standard also defines the request mechanisms and endpoint publishing strategy to enable a resource oriented architectural style based on web-based URL endpoints allowing clients to simply request resources as documents.

Requirement 2: A DGIWG WMTS server SHALL support REST and KVP architectural patterns/encoding techniques.

According to this requirement, a DGIWG WMTS server SHALL support the resource oriented architectural style with REST and KVP encodings.

NOTE 1: The intent of DGIWG Requirement 1, and DGIWG Recommendation 1 (see section 7.2. Recommendations for Implementation), is to increase interoperability opportunities with DGIWG WMTS servers. However, based upon the operational requirements for a specific system, a program may elect to reduce the number of supported architectural patterns/interfaces. It is anticipated that operational requirements such as increased security may drive optional implementations to adopt different security measures especially those enabled by SOAP encodings.

7.6 GetCapabilities

Requirement 3: A DGIWG WMTS server SHALL declare its support for GetCapabilities operations using KVP with HTTP GET

This requirement is supported by providing an OperationsMetadata section in the ServiceMetadata document with an Operation section for each supported HTTP request type. [Normative Reference **1**]

Requirement 4: A DGIWG WMTS server SHALL generate a ServiceMetadata document in response to a GetResourceRepresentation request in REST architecture.

In response to a valid request for a ServiceMetadata representation from a client, a DGIWG WMTS server will generate a document that conforms to the example described in section 7.1.1.3 of [Normative Reference **1**]

7.7 GetTile Request

Requirement 5: A DGIWG WMTS server SHALL support KVP encoding of the GetTile operation request using parameters specified in [Normative Reference 1, Table 29 (GetTile operation request URL parameters)].

DGIWG WMTS servers SHALL support KVP requests for representations of image tiles by declaring support for and correctly handling GetTile requests. The tile resource representation shall be returned in the format specified in the request when the format has been advertised in the ServiceMetadata document as available for that tile resource.

Requirement 6: A DGIWG WMTS server SHALL provide standard endpoints from which a representation of each tile resource can be obtained. [Normative Reference 1 P.44]

The ServiceMetadata document contains a list of Layer elements and each layer that is available to be retrieved shall have one or more <ResourceURL> elements with the “resourceType” attribute set to “tile” and a template attribute. The template attribute contains a URL template that can be converted to a URL by applying the rules shown in [Normative Reference 1, Table 32], URL template variables and possible values for tile. A standard HTTP GET is used to request the tile in the format specified by the attribute “format” as shown in [Normative Reference 1, Table 31, Parts of the URL Template data structure for tiles. P.62]

7.8 Coordinate Reference Systems

Requirement 7: A DGIWG WMTS server SHALL support the following coordinate reference systems:

- CRS:84 WGS84 geographic longitude, then latitude, expressed in decimal degrees
- EPSG:4326 WGS84 geographic latitude, then longitude, expressed in decimal degrees

7.9 Projections

Requirement 8a: A DGIWG WMTS server SHALL comply with one or more of the following projections:

- World Mercator Projection EPSG:3395

Requirement 8b: If projecting polar regions, a DGIWG WMTS server SHALL comply with one or more of the following projections:

- Universal Polar Stereographic Projection North EPSG:5041
- Universal Polar Stereographic Projection South EPSG:5042

7.10 Well-Known Scale Sets

Requirement 9: A DGIWG WMTS server SHALL employ the Well-Known Scale Sets identified in Annex B)

The list of map projections and their tiling schemes for global coverage is given in Table 7

Table 7: Tiling Schemes for Global Coverage

Tiled Projection Identifier	Map Projection	EPSG Code	Bounding Box	Zoom Levels	Description
MercatorFullyTiled	World Mercator	3395	Square	0 to 24	Mercator between +/- 85.05 degrees
WGS 84 (unprojected)	N/A	4326	Rectangular	1 to 24	-90 to 90; 180 to -180
UPSNorthTiled	UPS North	5041	Square	0 to 24	UPS centred on North Pole
UPSSouthTiled	UPS South	5042	Square	0 to 24	UPS centred on South Pole
NATO	World Mercator	3395	Xxx	0 to 29	xxx

a) NOTE: Web Mercator is a de facto standard used for web mapping applications. It is used by virtually all major online map providers, including Google Maps, Bing Maps, OpenStreetMap, Mapquest, Esri, Mapbox, and others. If using WMTS map data from a Volunteered Geographic Information (VGI) or commodity data source which is in the Web Mercator projection, it is highly recommended that your service warns users that this data is suitable for visualization use cases only and cannot be combined with other WMTS datasets as positioning will be different.

b) For a use case that requires precise locations and precise navigation (land, air, and sea) the World Mercator projection is mandated.

7.11 Tile File Formats

Requirement 10: A DGIWG WMTS server SHALL support at least one of the following raster formats for the GetTile operation:

- image/png (Portable Network Graphics)
- image/gif (Graphics Interchange Format)
- image/jpeg (Joint Photographic Experts Group)

Formats vary in utility to support thematic mapping, image quality, and transparency. Servers shall provide .png, .jpeg, and .gif to support varying utility and requirements. The png image format is recommended where transparency is needed. The jpeg image format is recommended where image quality is needed, and transparency is not. Since a GetTile operation can serve only one tile at a time, clients should have the ability to support transparency and also be able to overlap tiles from the same geographical area.

NOTE: Users should be aware that only the output formats GIF and PNG support transparency.

7.12 Negotiation of Standard Version

Requirement 11: *A DGIWG WMTS server support negotiation of the standard version used for client-server interactions (procedure oriented architectural style.*

The GetCapabilities operation includes a version-negotiation mechanism, allowing the client and server to agree on a standard version on which to base all future communication. The information below is an excerpt from [Normative Reference 1, Table 17], which describes the “accept Versions” parameter in the GetCapabilities operation request

Table 8: Accept Versions Parameter in GetCapabilities Operation Request

Names	Definition	Data type and	Multiplicity and use
accept Versions Accept Versions	Prioritized sequence of one or more standard versions accepted by client, with preferred versions listed first	Sequence of Character String type, each not empty Value is list of x.y.z —version‖ values. SHALL contain "1.0.0"	Zero or one (optional) When omitted, return latest supported version

7.13 Keywords

Requirement 12: *A DGIWG WMTS server SHALL* provide a minimum keyword list based on the DGIM (DGIWG Geospatial Information Model) groups.

NOTE 1: Annex C presents groups and subgroups for DGIM 2016-2.0.

- Aeronautical
- Biota
- Characteristics

- Demarcation
- Hydrography and Oceanography
- Industries and Services
- Metadata and References
- Military
- Names and Designations
- Physiography
- Socio-economic Geography
- Transportation
- Weather and Climate

NOTE: Additional keywords may be added to the list as appropriate to support data discovery.

- Zero or more Styles may be advertised for a Layer or collection of layers using <Style> elements, each of which shall have <Name> and <Title> elements.
  - The style's **Name** is used in the Map request STYLES parameter.
  - The **Title** is a human-readable string. If only a single style is available, that style is known as the “default” style and need not be advertised by the server.

7.14 Metadata

Requirement 13: ***A DGIWG WMTS server*** **SHALL** ***provide all service metadata elements based upon guidance in the [Normative Reference 1 – section 7.1: Services Identification] as well as all relevant mandatory metadata elements defined in the Minimum Mandatory Metadata outlines in [Normative Reference 1].***

7.15 Cacheable Resources

Requirement 14: ***A DGIWG WMTS server*** **SHALL** ***provide the “tile expiration date” as part of the data caching information***

Provision of expiration information is important because it improves the efficiency of client caching thereby reducing the WMTS server load and ultimately reducing the load time for users. To enable efficient web caching, a DGIWG WMTS server shall include expiration date in the server responses.

Caching works by marking certain data as being needed to be updated at different intervals. For example, information on a 1:5,000,000 scale Joint Navigation Chart (JNC) is relatively static and is unlikely to change from one month to the next. By caching the tiles associated with the JNC, the client is able to only download this information as needed, e.g., once a year. By the server telling the client to store these files and not download them when revisiting the geographic area, display performance is improved and network bandwidth is conserved. Conversely, for information that may change rapidly, such as weather data, the update interval may be set to expire in a very short timeframe, possibly on the order of minutes.

Internally caching this is achieved by means of the proper HTTP control headers:

HTTP 1.0 uses the "Expires" header. This header indicates an expiration date. If your data is guaranteed to be static, or you know when the data is going to be updated, you can use a convenient future date in the Expires header.

HTTP 1.1 uses the "Cache-control" header. This header indicates a period of time to

cache the data before expiration. If your data is guaranteed to be static, or you know when the data is going to be updated, you can use a convenient period of time in the Cache-control header.

Client caching capabilities will vary greatly and should be designed around a number of considerations to include data latency, currency requirement, area of interest coverage requirements, storage capacity, and network connectivity.

7.16 Recommendations for Server Implementation

Recommendation 1: A DGIWG WMTS server should support SOAP encodings, if required.

Recommendation 2: If a service requires feature coordinate information, it is recommended that FeatureInfo documents be offered in the MIME type format "application/gml+xml; version=3.2".

Recommendation 3: The themes section of a DGIWG WMTS service metadata document should contain data about how layers are organized thematically.

In the Contents section of WMTS, layers are represented as a linear list without hierarchy, and a hierarchy of themes is specified separately in the themes section, removing the need to specify complex inheritance rules for layer properties. This separates both concepts and makes it easy for a client to ignore the theme hierarchy or even to force another layer organization. Also, it allows servers to offer more than one-layer organization (in more than one themes section).

Each theme has a human-readable description (i.e., a title) and a list of layer references and child themes. It is possible for a layer to be a member of more than one theme, and for a layer to exist without being a member of any theme.

The reference for designation of theme names is the Defence Geospatial Information Framework (DGIF), which are listed in Annex C of this standard. Appropriate theme names are to be determined at the schema package bundle level, i.e., Transportation, or at the Schema Package level, i.e., Inland Water Transportation and Associated Features, Railways and Associated Features, etc.

8. DGIWG Queryable WMTS Profile

8.1 Normative Requirements

The Normative requirements requested by this conformance class are summarized inTable 9

Table 9: DGIWG Queryable WMTS Normative Server Requirements

No.	Requirement	Compliance
15	A DGIWG Queryable WMTS server SHALL be compliant to the DGIWG WMTS Basic and the Queryable WMTS conformance classes.	M
16	A DGIWG Queryable WMTS server SHALL support text/xml and text/html as output format for the GetFeatureInfo operation.	M
17	A DGIWG WMTS server SHALL include the following information in the abstract element of the service metadata: “This service implements the DGIWG WMTS profile version 1.0, DGIWG Queryable WMTS conformance class (URI) (http://www.dgiwg.org/std/wmts/1.0/conf/queryable).”	M
18	A DGIWG WMTS server SHALL implement HTTP GET transfer of the GetFeatureInfo operation request using KVP encoding	M
19	A DGIWG WMTS server SHALL provide standard endpoints from which representation of the FeatureInfo resources can be obtained. [Normative Reference 1 P.49]	M

8.2 Service Type

According to this profile a Queryable WMTS includes all Basic WMTS operations and an additional GetFeatureInfo operation.

Requirement 15: A DGIWG Queryable WMTS server SHALL be compliant to the Basic WMTS and Queryable WMTS conformance classes.

8.3 Basic Service elements

8.3.1 Output Formats

The response to a Web Map Tile Service request is always a computer file. The file may contain text, or the file may represent a map image depending on the operation. For the particular operations a DGIWG WMTS server shall support the following output formats.

8.3.2 Output formats for GetFeatureInfo requests

The response to a GetFeatureInfo request is always a text file.

Requirement 16: A DGIWG Queryable WMTS server SHALL support text/xml and text/html as output format for the GetFeatureInfo operation.

8.4 Operations

8.4.1 GetCapabilities Operation Response

Requirement 17: A DGIWG WMTS server SHALL include the following information in the abstract element of the service metadata: "This service implements the DGIWG WMTS 1.0 profile version 1.0, DGIWG Queryable WMTS conformance class* (URI) *(http://www.dgiwg.org/std/wmts/1.0/conf/queryable)."

NOTE: this requirement replaces the WMTS Basic requirement that advertises for support of the DGIWG Basic conformance class.

8.5 GetFeatureInfo Request

Requirement 18: A DGIWG WMTS server SHALL implement HTTP GET transfer of the GetFeatureInfo operation request using KVP encoding.

KVP encoding of the GetFeatureInfo operation request shall follow the requirement for operation parameters specified in Table **10** below and that follows the abstract description specified in [Normative Reference 1, Table **25**].

Table 10: GetFeatureInfo operation request URL parameters

ID	Request Parameter	OGC Mandatory/Optional	DGIWG Mandatory/Optional	Definition and Format
1	Service=WMTS	M	M	Service type identifier
2	Request=GetFeature Info	M	M	Operation name
3	Version=1.0.0	M	M	Standard and schema version for this operation
4	Layer	O use of these parameters SHALL match those in the corresponding GetTile request described in [Table **29,** Normative Reference 1]	M	Layer Identifier
5	Style	O	M	Style Layer Identifier
6	Format	O	M	Output format of File
7	Sample dimensions	O	M	Value allowed for this dimension
8	TileMatrixSet	O	M	Value allowed for this dimension
9	TileMatrix	O	M	TileMatrix identifier

ID	Request Parameter	OGC Mandatory/Optional	DGIWG Mandatory/Optional	Definition and Format
10	TileRow	O	M	Row index of the Matrix
11	TileCol	O	M	Column index of the Matrix
12	J	M	M	Row index of a pixel in the tile
13	I	M	M	Column index of a pixel in the tile
14	InfoFormat	M	M	Output format of the retrieved information
a Names for this parameter shall be the names indicated in the ServiceMetadata document as described in Normative Reference 1 . Typical examples are Time, Elevation, and Band				

Requirement 19: A DGIWG WMTS server SHALL provide standard endpoints from which representation of the FeatureInfo resources can be obtained. [Normative Reference 1 P.49]

The ServiceMetadata document contains a list of Layer Elements and each layer that is available to be retrieved and is queryable shall have on or more <ResourceURL> elements with the “resourceType” attribute set to “FeatureInfo” and a template attribute. The template attribute contains a URL template that can be converted to a URL by using a template processor. The FeatureInfo is obtained in the format specified by the attribute “format” by requesting the resource with a standard HTTP GET. **P.65**

9. Client Requirements and Recommendations

This section describes the normative requirements for client implementations of the DGIWG Profile

Table 11: Normative WMTS Client Requirements

No.	Category	Modifier	DGIWG Client Requirement	Compliance
1	Architectural Patterns/Encoding	N/A	A DGIWG WMTS client SHALL support REST	M
2	GetCapabilities	KVP	A DGIWG WMTS client SHALL support a GetCapabilities operation by sending a GET or POST HTTP message with the “request” parameter set to “GetCapabilities.	M
3		SOAP	A DGIWG WMTS client should be capable of issuing SOAP encoded GetCapabilities operation requests.	O
4		REST	A DGIWG WMTS client SHALL issue a GetResourceRepresentation request to access a Service Metadata document by requesting a file using the URL.	M
5	GetTile	KVP	A DGIWG WMTS client SHALL support KVP encoding of the GetTile operation request using parameters specified in Normative Reference 1, Table 29 (GetTile operation request URL parameters).	M
6		SOAP	A DGIWG WMTS client shall support SOAP encoding using HTTP POST transfer of the GetTile operation request, using SOAP 1.2.	O
7		REST	A DGIWG WMTS client SHALL request a tile representation using a tile URL.	M
8	GetFeatureInfo	KVP	A DGIWG WMTS client shall provide the capability to obtain more information for a pixel (I,J) on a particular tile by using data parameters as specified in Normative Reference 1, Figure 11 and Table 25.Only if implementing a Queryable WMTS	C
9		SOAP	A DGIWG WMTS client shall provide the capability to obtain more information for a pixel (I,J) on a particular tile by SOAP encoding the GetFeatureInfo request.	O
10		REST	A DGIWG WMTS client shall have the capability to query those layers with one or more <ResourceURL> elements with the “resourceType” attribute set to “FeatureInfo” and a template attribute. Only if implementing a Queryable WMTS	C

No.	Category	Modifier	DGIWG Client Requirement	Compliance
11	Coordinate Reference systems	N/A	A DGIWG WMTS client SHALL support the following coordinate reference systems: • CRS:84 WGS84 geographic longitude, then latitude, expressed in decimal degrees • EPSG:4326 WGS84 geographic latitude, then longitude, expressed in decimal degrees	M
12	Projections	N/A	A DGIWG WMTS client SHALL support the following projections whose validity zones overlap data published by the service: • World Mercator Projection…EPSG:3395 • UPS projection over WGS84 (north zone)…… EPSG:5041 • UPS projection over WGS84 (south zone)…… EPSG:5042	M
13	Well-Known Scale Sets	N/A	A DGIWG WMTS client SHALL support the Well-Known Scale Sets identified in Annex B	M
14	Tile Formats	N/A	A DGIWG WMTS client SHALL support image/png, image/jpeg, and image/gif file formats.	M
15	Negotiation of Standard Version	SOAP	A DGIWG WMTS client shall support negotiation of the standard version used for client-server interactions.	O
16	Key Word List	N/A	A DGIWG WMTS server SHALL have a minimum keyword list based on the Defence Geospatial Information Framework (DGIF) Groupings	M
17	Metadata	N/A	A DGIWG WMTS server SHALL provide all service metadata elements based upon the DGIWG Metadata Foundation (DMF) v2.0.	M
18	Cacheable Resources	N/A	A DGIWG WMTS client SHALL support caching information (expiration date) for the data.	M
19	Output Format (GetFeatureInfo)	N/A	A DGIWG WMTS client shall support the GetFeatureInfo output format in text/XML and text/HTML. Only if implementing a Queryable WMTS	C

Annex A

DGIWG Abstract Test Suite (Normative)

A.1 Introduction

This abstract test suite specifies at a high level how server and client implementations of this standard SHALL be tested for conformance to this standard. The framework for such abstract test suites is specified in ISO 19105: Geographic information – Conformance and testing, especially Clauses 7 and 9.

An abstract test suite contains multiple abstract tests, grouped into one or more test modules. This abstract test suite consists of two top-level test modules:

a) Server test module – Abstract tests for checking conformance of server implementations with the requirements of this standard that are normatively referenced by this Implementation Specification.

b) Client test module – Abstract tests for checking conformance of client implementations with the requirements of this standard that are normatively referenced by this Implementation Specification.

Any of these modules could contain lower-level test modules. At this time, only the Server test module contains lower-level test modules, namely:

a) All operations implemented test module – Abstract tests for checking server properties that are common to all operations implemented.

b) GetCapabilities, GetTile and GetFeatureInfo operation test module – Abstract tests for checking server properties that are specific to an operation.

In the client and server test modules, all operations specified and implemented SHALL be tested, including KVP HTTP GET, and SOAP HTTP POST transfer and RESTFul HTTP GET transfer of each operation request. In the standard test module, all operations specified SHALL be checked, including KVP HTTP GET, SOAP HTTP POST and RESTFul HTTP GET transfer of operation requests. And all operation request and response parameters specified or implemented SHALL be tested. Of course, some operations, transfer methods, and parameters are specified as optional implementation by servers. Any optional item not implemented by a server SHALL not be tested. Also, items not implemented by a client SHALL not be tested.

A.2 Server test module (DGIWG Basic WMTS)

DGIWG Requirement 1: A DGIWG Basic WMTS server SHALL be compliant to the Basic WMTS conformance class

a) Test Purpose:

Verify that a DGIWG WMTS server satisfies all requirements for an OGC WMTS conformance class (DGIWG Requirement 1)

b) Test Method:

Submit a GetCapabilities and a GetTile requests to the server and verify that it is providing proper responses.

c) References:

Clauses all 7

d) Test Type:

Capability

DGIWG Requirement 2 and 3: A DGIWG WMTS server SHALL support REST and KVP.

a) Test Purpose:

Verify that a server is capable of handling procedure-oriented architectural style through KVP encoding as well as Resource Oriented Architectural style through REST encoding

b) Test Method:

This requirement is satisfied upon successful completion of testing for the following Requirements: 2, 3, 4, 5, 7, 8, and 10.

c) Reference:

Clause 7.5

d) Test Type:

Capability

DGIWG Requirement 3: A DGIWG WMTS server SHALL declare its support for

GetCapabilities operations using KVP with HTTP GET by providing an OperationsMetadata section in the ServiceMetadata document with an Operation section for each supported HTTP request type.

a) Test Purpose:

Verify that a server handles a URL service metadata request.

b) Test Method:

Submit HTTP GET and/or HTTP POST transferred requests for each operation. Verify that the server accepts and responds to these requests as specified and implemented. Check that the server accepts at least one HTTP GET or HTTP POST transfer of requests for GetCapabilities operation.

c) Reference:

Clause 7.6

d) Test Type:

Capability

DGIWG Requirement 4: A DGIWG WMTS server SHALL generate a ServiceMetadata document in response to a GetResourceRepresentation request in REST architecture that looks like the one described in section 7.1.1.3 of Normative Reference 1.

a) Test Purpose:

Verify that a server generates a ServiceMetadata document in response to a GetResourceRepresentation request.

b) Test Method:

Request a Service metadata URL and other URL resources using correct and incorrect URLs. Verify that the server respond with the right resource to correct URLs, and a returns HTTP errors for invalid URLs.

c) Reference:

Clause 7.6

d) Test Type:

Capability

Service Metadata Content

a) Test Purpose:

Verify that A DGIWG WMTS server satisfies all Service Metadata requirements for a GetCapabilities operation request (procedure oriented architectural style) or a resource request (resource oriented architectural style) (Requirements 3 and 4).

b) Test Method:

Submit a GetCapabilities or operation request and verify the following:

1. The response has all required service metadata elements.
2. The response uses <AccessContraints> to identify classification levels for the service.
3. The response in the Abstract element contains the following information: "This service implements the DGIWG WMTS 1.0.0 profile version 1.0."
4. The response provides keywords based upon the NAS for the following: Layer data structure, Style data structure, Dimension data structure, TileMatrixSet data structure, TileMatrix data structure, and Themes data structure.
5. The response provides information on the supported styles.
6. The response provides a defined style for the default style.
7. The response provides an associated legend in at least one of the following formats: PNG, GIF, JPEG.
8. The provided LegendURL is accessible online.
9. The response provides Dimension information, if applicable to a layer.
10. The response provides a valid output format for Layer data structure infoFormat parameter thus enabling GetFeatureInfo. The response provides scale denominators for all layers.
11. The provided <MinScaleDenominator> value is less than or equal to the <MaxScaleDenominator>.
12. The list of features is resolvable through the provided FeatureListURLs

13. The data is resolvable through the provided URL for all provided DatURLs.

c) Reference:

Clause 7.6

d) Test Type:

Capability

DGIWG Requirement 5: A DGIWG WMTS server SHALL respond to a GetTile operation request with a tile map that complies with the requested parameters.

a) Test Purpose:

Verify that for a KVP encoded GetTile operation, for each GetTile format, when the Format parameter is set to that format, the MIME type of the response matches that format.

b) Test method:

Pass if for each GetTile format, when the Format parameter is set to that format, the MIME type of the response matches that format.

c) Reference:

Clause 7.7

d) Test Type:

Capability

DGIWG Requirement 6: A DGIWG WMTS server SHALL provide standard endpoints from which a representation of each Tile resource can be obtained.

a) Test Purpose:

Verify that a server handles a URL service metadata request.

b) Test Method:

Request a Service metadata URL and other URL resources using correct and incorrect URLs. Verify that the server respond with the right resource to correct URLs, and a returns HTTP errors for invalid URLs.

c) Reference:

Clause 7.7

d) Test Type:

Capability

DGIWG Requirement 7: A DGIWG WMTS server SHALL be capable of providing tiles in the following coordinate reference systems:

- CRS:84 WGS84 geographic longitude, then latitude, expressed in decimal degrees
- EPSG:4326 WGS84 geographic latitude, then longitude, expressed in decimal degrees

a) Test Purpose:

Verify that a DGIWG WMTS server satisfies all the requirements for handling coordinate reference systems (DGIWG Requirement 11).

b) Test Method:

1. Submit requests and verify that all supported coordinate reference systems are advertised for all available data in the XML response (Capabilities document) to a valid GetCapabilities request.
2. Submit GetTile requests and verify that tiles are provided in appropriate projections for each validity zone.

c) Reference:

Clause 7.8

d) Test Type:

Capability

DGIWG Requirement 8 a & b: A DGIWG WMTS server SHALL support the following projections whose validity zones overlap data published by the service:

- World Mercator Projection…EPSG:3395
- DGIWG WMTS Projections

a) Test Purpose:

Verify that A DGIWG WMTS server satisfies all the requirements for handling projections (DGIWG Requirement 8).

b) Test Method:

1. Submit requests and verify that all supported CRS are advertised for all available data in the XML response (Capabilities document) to a valid GetCapabilities request.
2. Submit GetTile requests and verify that tiles are provided in appropriate projections for each validity zone.

c) Reference:

Clause 7.9

d) Test Type:

Capability

DGIWG Requirement 9: A DGIWG WMTS server SHALL employ the Well-Known Scale Sets identified in Annex B (based upon World Mercator projection EPSG 3395 and WGS 84 Geodetic EPSG 4326)

a) Test purpose:

Verify that the WellKnownScaleSets identified in Annex B is employed.

b) Test method:

Submit requests and verify that the WellKnownScaleSet that is advertised conforms to the tiling scheme identified in Annex B. That is the different ScaleDenominators with values starting from the largest scale denominator in the WellKnownScaleSet table and all intermediate scale denominators are represented.

c) Reference:

Clause 7.10

d) Test type:

Capability

DGIWG Requirement 10: A DGIWG WMTS server SHALL offer tiles in the image/png, image/jpeg, and image/gif file formats.

a) Test Purpose:

Verify that A DGIWG WMTS server satisfies all the requirements for supported outputs.

b) Test Method:

Submit requests and verify that the server implements support for:

1. Submit a GetCapabilities request (FORMAT = text/html) and verify that the response is text/html
2. Submit a GetFeatureInfo request (FORMAT = text/html) and verify that the response is text/html
3. A response to a "GetCapabilities" request in English language
4. Submit a GetTile request (FORMAT = image/png) and verify that the response is image/png
5. Submit a GetTile request (FORMAT = image/gif) and verify that the response is image/gif
6. Submit a GetTile request (FORMAT = image/jpeg) and verify that the response is image/jpeg.

c) Reference:

Clause 7.11 (Subclause 7.3.2 of OWS Common [OGC 06-121r3])

d) Test Type:

Capability

DGIWG Requirement 11: A DGIWG WMTS server SHALL support negotiation of the standard version used for client-server interactions (procedure oriented architectural style).

a) Test Purpose:

Verify that a server satisfies the requirements for version negotiation.

b) Test Method:

Submit GetCapabilities operation requests containing version numbers lower than, higher than, and equal to the version supported by the server. Verify that the server responses are in accord with the specified rules for version negotiation.

c) Reference:

Clause 7.12 (Subclause 7.3.2 of OWS Common [OGC 06-121r3])

d) Test Type:

Capability

DGIWG Requirement 12: A DGIWG WMTS server SHALL have a minimum keyword list based on the Defence Geospatial Information Framework -2 (DGIF-2) Groupings as summarised in annex C of this document.

a) Test Purpose:

Verify that a server satisfies the requirements for use of the DGIWG Application Schema.

b) Test Method:

Submit a GetCapabilities request and verify that the response implements guidance provided in DMF Part 5 as well as relevant mandatory metadata elements defined in DMF Part 1.

c) Reference:

Clause 7.13

d) Test Type:

Capability

DGIWG Requirement 13: A DGIWG WMTS server SHALL provide all service metadata elements based upon the DGIWG Metadata Foundation (DMF).

a) Test Purpose:

Verify that a server satisfies the requirements for use of the DGIWG Metadata Foundation.

b) Test Method:

Submit a GetCapabilities request and verify that the response provides a keywordlist that is based on the DGIWG Application Schema.

c) Reference:

Clause 7.14

d) Test Type:

Capability

DGIWG Requirement 14: A DGIWG WMTS server SHALL provide caching information (expiration date) for the data.

a) Test Purpose:

Verify that a server provides caching information for the data.

b) Test Method:

Submit a GetTile request and verify that the response provides caching information for tile data returned by the server..

c) Reference:

Clause 7.15

d) Test Type:

Capability

A.3 Server test module (Queryable WMTS)

Requirement 15: A DGIWG Queryable WMTS server SHALL be compliant to the DGIWG WMTS Basic and the Queryable WMTS conformance classes.

a) Test Purpose:

Verify that a DGIWG Queryable WMTS server satisfies all requirements for a DGIWG Basic WMTS (DGIWG Requirement 1 to 14) and a Querryable WMTS (DGIWG Requirement 15 to 19)

b) Test Method:

See Annex A.2 and A.3

c) References:

N/A

d) **Test Type**:

Capability

DGIWG Requirement 16: A DGIWG WMTS server SHALL provide the GetFeatureInfo output format in text/XML and text/HTML.

a) Test Purpose:

Verify that a server provides GetFeatureInfo in a text/XML or text/HTML format.

b) Test Method:

Submit a GetFeatureInfo request and verify that the response is in text/XML or text/HTML format.

c) Reference:

Clause 8.3

d) Test Type:

Capability

DGIWG Requirement 17: A DGIWG WMTS server SHALL include the following information in the abstract element of the service metadata: "This service implements the DGIWG WMTS profile version 1.0, DGIWG Queryable WMTS conformance class (URI) (http://www.dgiwg.org/std/wmts/1.0/conf/queryable)."

a) Test Purpose:

Verify that A DGIWG Queryable WMTS interface satisfies requirement 17 by adding the correct text to the abstract in the GetCapabilities response.

b) Test Method:

Submit a GetCapabilities request and verify that the response in the Abstract element contains the following information: " shall include the following information in the abstract element of the service metadata: "This service implements the DGIWG WMTS profile version 1.0, DGIWG Queryable WMTS conformance class (URI) (http://www.dgiwg.org/std/wmts/1.0/conf/queryable)."

c) Reference:

Clause 8.4

d) Test Type:

Capability

DGIWG Requirement 18: A DGIWG WMTS server SHALL implement HTTP GET transfer of the GetFeatureInfo operation request using KVP encoding.

a) Test Purpose:

Verify that A DGIWG WMTS interface satisfies all requirements for the operation GetFeatureInfo.

b) Test Method:

Submit a GetFeatureInfo request from the client and verify that an appropriate response is returned according to the requested InfoFormat.

c) Reference:

Clause 8.5

d) Test Type:

Capability

DGIWG Requirement 19: A DGIWG WMTS server shall provide standard endpoints from which representation of the FeatureInfo resources can be obtained.

a) Test Purpose:

Verify that a server satisfies RESTful requests

b) Test Method:

Verify that the server provides a Service Metadata document that includes complete ResourceURL information with resourceType=tile on Layer section if tiles of this layer are able for RESTful.

c) Reference:

Clause 8.5

d) Test Type:

Capability

Annex B
Well-known Scale Sets
(Normative)

Note: All WKSS defined here are designed to be used for 256 x 256 pixel tiles.

B.1 World Mercator EPSG:3395[2]

The World Mercator (EPSG::3395) well-known scale set is defined in this DGIWG WMTS Implementation Interoperability Profile. To be conformant to this well-known scale set, a WMTS server SHALL allow responses from the largest scale denominator in Table 8 and all intermediate scale denominators down to the most detailed scale resolution of that data. It is therefore not required to support the smallest scale denominator in order to be conformant to a well-known scale set.

The World Mercator (EPSG::3395) WMTS tile scheme has a square layout.

The projection bounds for the World Mercator raster tile pyramid are (-20037508.342789244, -20037508.342789244) to (20037508.342789244, 20037508.342789244) meters which yields the corresponding longitude, latitude limits of (-180, -85.084059) to (180, 85.084059)

The zoom level 0 tile covers the whole bounds of the projection which yields an area of 40,075,016.68557849 meters by 40,075,016.68557849 meters.

As referenced in Normative Reference 1, section 6.1. a) "The scale denominator is defined with respect to a 'standardized rendering pixel size' of 0.28 mm × 0.28 mm (millimeters) and the WGS84 equatorial earth circumference.

Two hundred fifty six (256) pixels in the horizontal dimension are defined to be 71.68 mm or 0.07168 meters. It represents 40,075,016.68557849 meters of Earth distance. Thus, the scale is 40,075,016.68557849 / 0.07168 or 559082264.0287178.

At zoom level 0, the pixel size in meters is 40,075,016.68557849 / 256 = 156543.033928041.

Scales and pixel sizes for the 3395 projection match the GoogleMapsCompatible scale set, even though the projections are different. The actual tile contents will also differ slightly.

The zoom level scale set and matrix width and height for the World Mercator raster tile pyramid are defined below in Table **12**

[2] EPSG Geodetic Parameter Registry (http://www.epsg-registry.org/)

Table 12: Zoom Level Scale Set and Matrix Dimensions-EPSG:3395

Zoom Level	Scale	Pixel Size (m)	*matrix_width*	*matrix_height*
0	559082264.028718	156543.033928041	1	1
1	279541132.014359	78271.5169640205	2	2
2	139770566.007179	39135.7584820103	4	4
3	69885283.0035897	19567.8792410051	8	8
4	34942641.5017949	9783.9396205026	16	16
5	17471320.7508974	4891.9698102513	32	32
6	8735660.37544872	2445.9849051256	64	64
7	4367830.18772436	1222.9924525628	128	128
8	2183915.09386218	611.4962262814	256	256
9	1091957.54693109	305.7481131407	512	512
10	545978.773465545	152.8740565704	1024	1024
11	272989.386732772	76.4370282852	2048	2048
12	136494.693366386	38.2185141426	4096	4096
13	68247.3466831931	19.1092570713	8192	8192
14	34123.6733415965	9.5546285356	16384	16384
15	17061.8366707983	4.7773142678	32768	32768
16	8530.9183353991	2.3886571339	65536	65536
17	4265.4591676996	1.194328567	131072	131072
18	2132.7295838498	0.5971642835	262144	262144
19	1066.3647919249	0.2985821417	524288	524288
20	533.1823959624	0.1492910709	1048576	1048576
21	266.5911979812	0.0746455354	2097152	2097152
22	133.2955989906	0.0373227677	4194304	4194304
23	66.6477994953	0.0186613839	8388608	8388608
24	33.3238997477	0.0093306919	16777216	16777216

All tiles are globally referenced based on the zoom level and (column, row) index values on the global World Mercator grid. Figure 1 below shows the (column, row) index values for zoom levels 0 through 3.

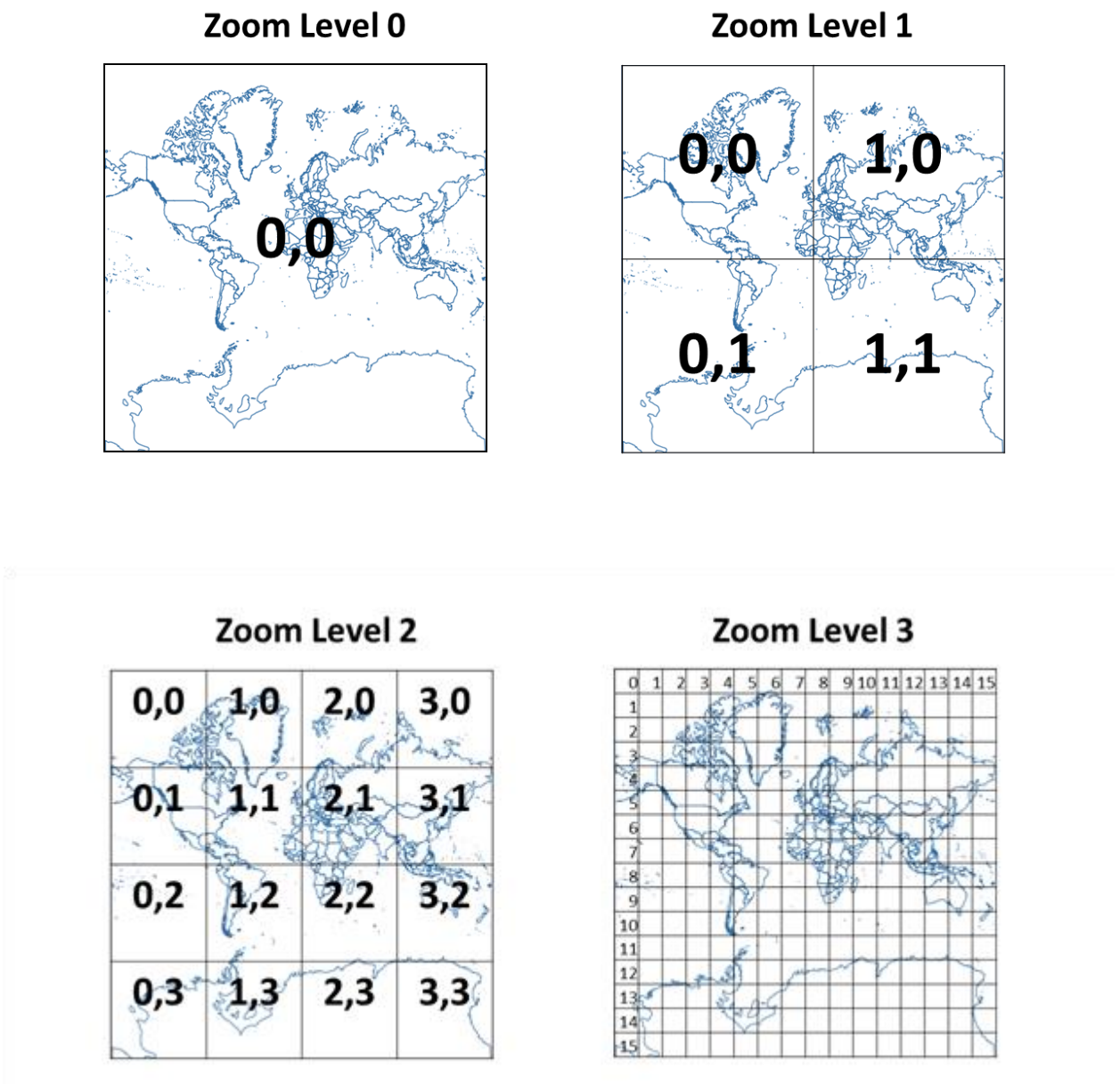

Figure 1: World Mercator tile indexing

The bounding box should describe the maximum extent of the tiles. If source data does not completely fill a tile, pixels without data within the tile must be completely filled with a default value (e.g. transparency). The bounding box must be aligned with tile boundaries, not to data boundaries (Figure 2).

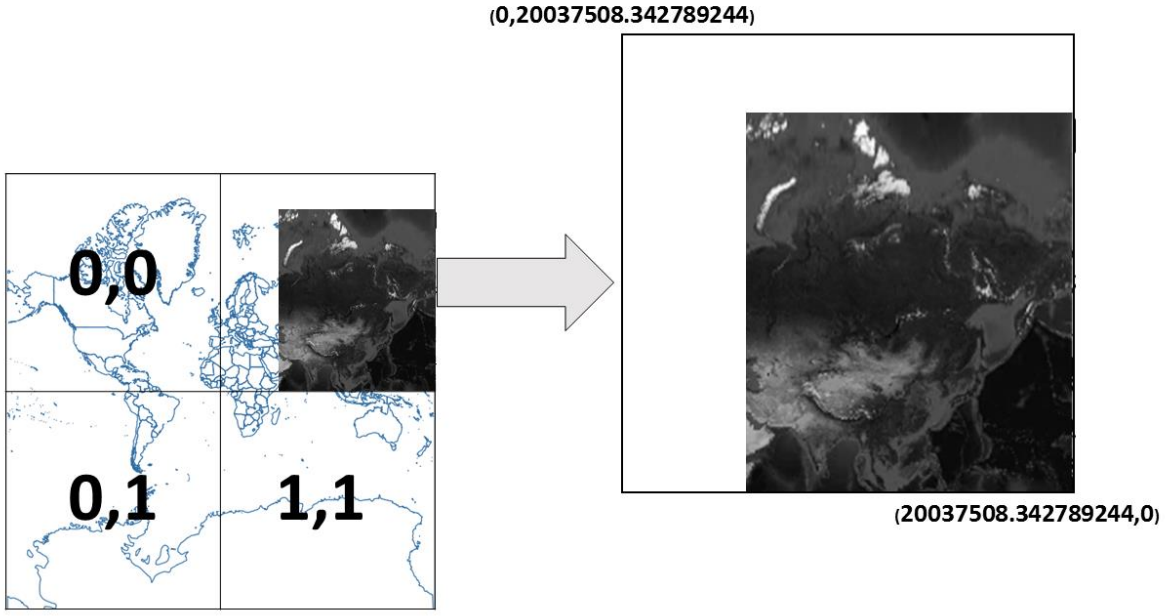

Figure 2: Bounding box and partial tile example

B.1.1 XML Description

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B.2 WGS 84 Geodetic lat/long EPSG:4326[3] and CRS 84

The WGS 84 Geodetic lat/long (EPSG::4326) tile scheme has an equirectangular layout.

The projection bounds for the WGS 84 Geodetic raster tile pyramid are (-180, -90) to (180, 90)

A zoom level 0 tile should generally not be used in the WGS 84 Geodetic tiling scheme. Zoom level 1 will consist of two square tiles that cover the whole bounds of the projection.

As referenced in the Normative Reference 1, section 6.1. a) "The scale denominator is defined with respect to a 'standardized rendering pixel size' of 0.28 mm × 0.28 mm (millimeters)"

At zoom level 1, the pixel size in degrees is 180/ 256 = 0.7031250.

The zoom level scale set and matrix width and height for the WGS 84 Geodetic raster tile pyramid are defined below in Table 12.

These scale sets are compatiable with WKSS defined in ANNEX E.3 of the OGC WMTS Standard Table E.1 GlobalCRS84Scale (urn:ogc:def:wkss:OGC:1.0:GlobalCRS84Scale), document ID; 07-057r7

Table 13: Zoom Level Scale Set and Matrix dimensions- WGS 84 Geodetic lat/long

Zoom Level	Pixel Size (degrees)	matrix_width	matrix_height
1	0.7031250	2	1
2	0.3515625	4	2
3	0.1757813	8	4
4	0.0878906250	16	8
5	0.0439453125	32	16
6	0.0219726563	64	32
7	0.0109863281	128	64
8	0.0054931641	256	128
9	0.0027465820	512	256
10	0.0013732910	1024	512
11	0.0006866455	2048	1024
12	0.0003433228	4096	2048
13	0.0001716614	8192	4096
14	0.0000858307	16384	8192

[3] EPSG Geodetic Parameter Registry (http://www.epsg-registry.org/)

Zoom Level	Pixel Size (degrees)	matrix_width	matrix_height
15	0.0000429153	32768	16384
16	0.0000214577	65536	32768
17	0.0000107288	131072	65536
18	0.0000053644	262144	131072
19	0.0000026822	524288	262144
20	0.0000013411	1048576	524288
21	0.0000006706	2097152	1048576
22	0.0000003353	4194304	2097152
23	0.0000001676	8388608	4194304
24	0.0000000838	16777216	8388608

All tiles are globally referenced based on the zoom level and (column, row) index values on the global WGS 84 Geodetic grid. Figure 3 below shows the (column, row) index values for zoom levels 1 through 3.

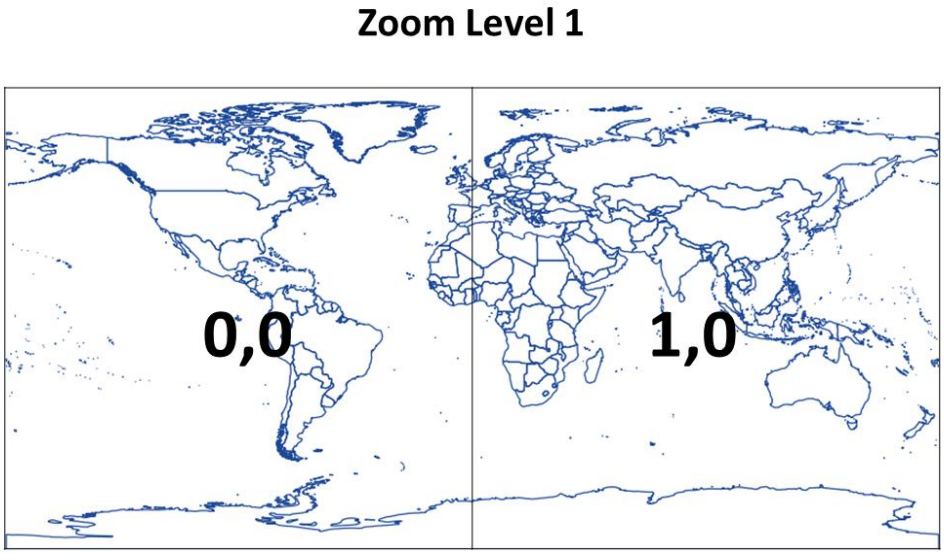

Figure 3: WGS 84 Tile Indexing – Zoom Level 1

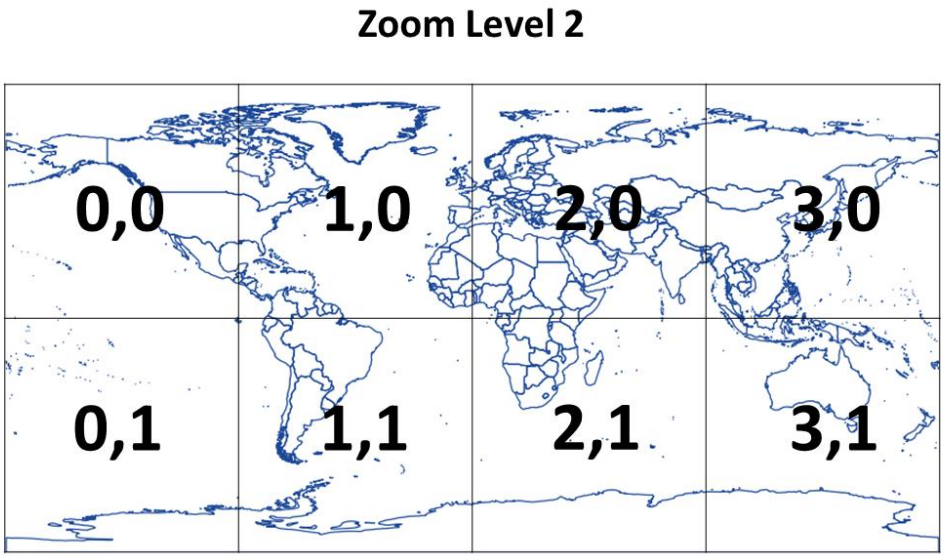

Figure 4: WGS 84 Tile Indexing – Zoom Level 2

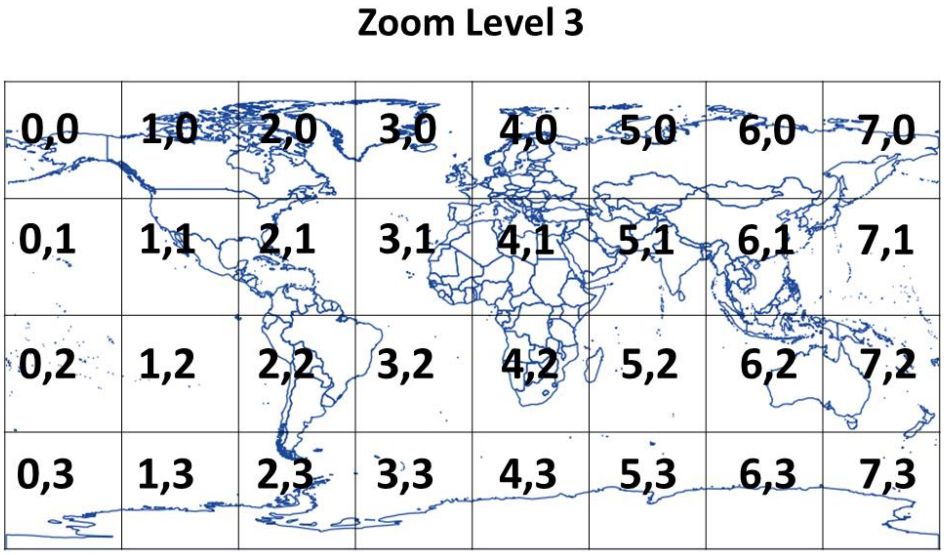

Figure 5: WGS 84 Tile Indexing – Zoom Level 3

B.3 UPS Tiles EPSG:5041 and EPSG:5042

EPSG:5041 refers to a coordinate reference system having axes and coordinates in the order Easting-Northing. It is employed by NATO in the Northern hemisphere – north of 60 degrees N onshore and offshore, including Arctic. EPSG: 32661 refers to a similar system having axes and coordinates in the order Northing-Easting.

EPSG:5042 refers to a coordinate reference system having axes and coordinates in the order Easting-Northing. It is employed by NATO in the Southern hemisphere – south of 60 degrees S onshore and offshore, including Antarctica. EPSG: 32761 refers to a similar system having axes and coordinates in the order Northing-Easting.[4]

B.4 Implementation Guide for UPS Tiles

UPS North (Full Tiling)

This section and the next specify the tiliing scheme for the zoom-able tiled raster graphics, when the map projection is the polar stereographic projection. This was specified in **SIG.0014_1.0_PROJRAS** but is amended here.

The map projection is Universal Polar Stereographic (UPS) or EPSG:: 5041, but with these limits for the UPS coordinates (x,y):

$$-14\,440\,759.3502 \leq x\, 18\,440\,759.350252$$
$$-14\,440\,759.3502 \leq y\, 18\,440\,759.350252$$

In the UPS System, the north Pole is assigned the coordinates $x = 2\,000\,000\; y = 2\,000\,000$. The above projection limits can be expressed another way to show the symmetry about the Pole:

$$-16\,440\,759.3502 \leq x - 2\,000\,000 \leq 16\,440\,759.350252$$
$$-16\,440\,759.3502 \leq y - 2\,000\,000 \leq 16\,440\,759.350252$$

The formulas for UPS grid coordinates, given the latitude and longitude, are available in many places, including the NGA document, **SIG.0012_2.0.0_UTMUPS.** In this application of UPS coordinates, negative values are allowed.

[4] EPSG Geodetic Parameter Registry (http://www.epsg-registry.org/)

The above limits are calculations based on the stipulation that the level 0 tile (a square) will be tangent on all four sides to circle at latitude 15^0S. This is shown in Fig. 6. More detail is given in Fig. 7.

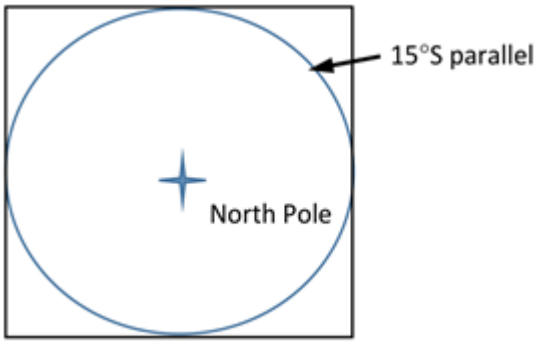

Figure 6: Tile to the parallel circle of latitude 15°S

Figure 6. The UPS plane showing the tile (square) on zoom level 0. This is the portion of the world to be tiled. The tile is tangent on all four slides to the parallel circle of latitude 15°S

The tiling scheme is given as follows:

- Tiles are squares with 256 pixels on a side
- Successive zoom-levels are built by dividing each tile in half, both horizontally and vertically to get twice as many tiles across and twice as many tiles down
- At zoom level 0 there is only one tile. It spans the limits of the projection given above.

The tiles are organized into rows and columns. At every zoom level, row 0 is at the top and column 0 is at the left. Fig. 3 shows the arrangment of tiles for zoom level 1. Fig. 9 shows the same for zoom level 2.

UPS South (Full Tiling)

The situation for UPS South is similar to the foregoing. The EPSG code is EPSG:: 5042. The x- and y-limits of projections are the same. It is symmetric in every way to UPS North, except, of course, the geography is different. Fig. 7 shows the portions of the world covered:

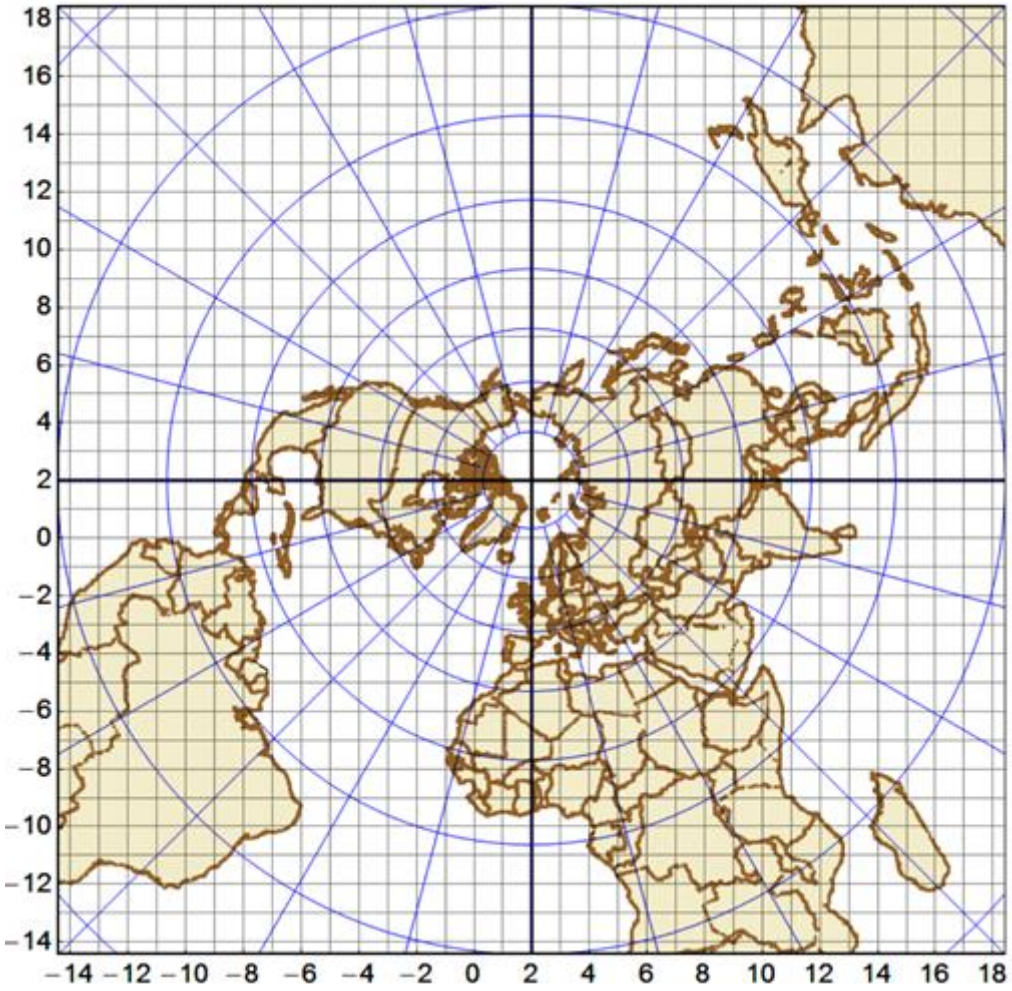

Figure 7: The outside square single tile for zoom level 0

Figure 7. The outside square is the single tile for zoom level 0. It's center is the North Pole with UPS coordinates (*x,y*) = (2 000 000, 2 000 000). Zoom level 1 is obtained by dividing it into 4 squares that abut each other along the 90°W, 0°E, 90°E and 180°E meridians. The labels on the *x*- and *y*- axes are millions of meters, and USP grid lines are shown every one million meters. Shown in blue are meridians and parallels at 15° intervals from the Prime Meridian and Equator, respectively. Small pieces of the 30°S parallel are shown.

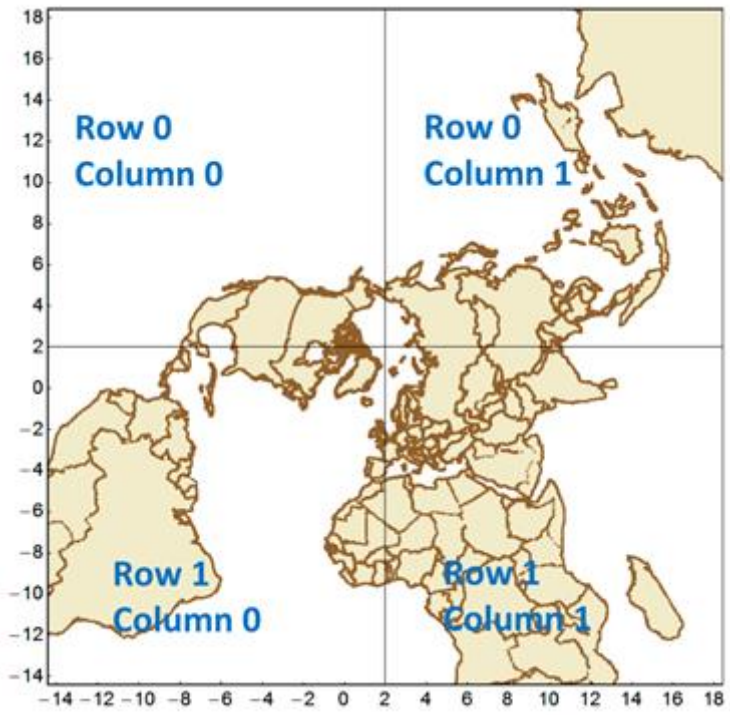

Figure 8: Numbering of tile rows and tile columns for zoom level 1.

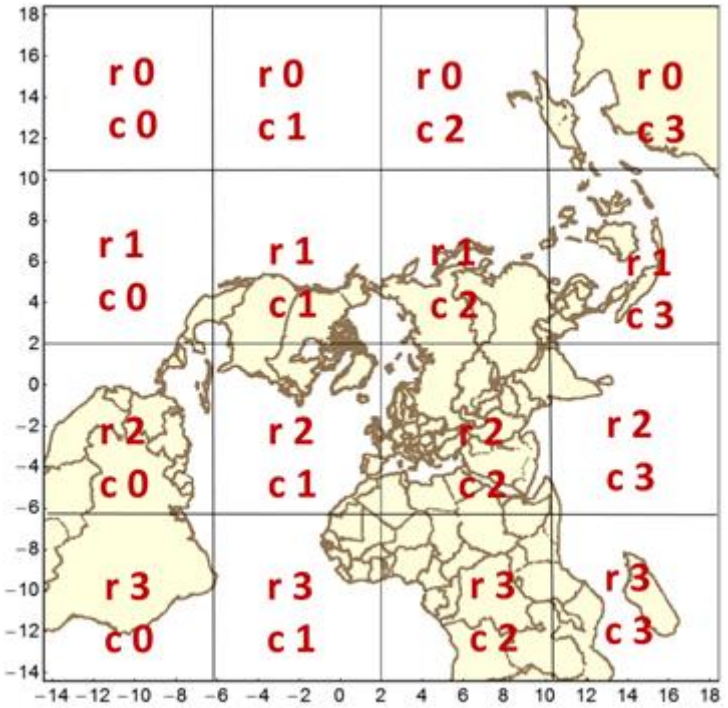

Figure 9: Numbering of tile rows (r) and columns (c) for zoom level 2.

For each zoom level n, there are 2^n tiles across and 2^n tiles down. Each tile is 256 pixels across by 256 pixels down. Therefore, the total number of pixels at zoom-level n that lie on the x-axis between $x = -14\,440\,759.350252$ and $x = 18\,440\,759.350252$ (an interval of length of $32\,881\,518.700504$ is $256 * 2^n = 2^{n+8}$. The ratio of meters on the x-axis to pixels on the x-axis is therefore:

$\frac{32\,881\,581.700504}{2^{n+8}}$meters/pixels

The meters/pixel ratio for the y-axis is the same. One pixel on the x- or y-axis is the above number of meters. One pixel on the small-device screen is assumed to be 0.28mm. This is a conventional number, and treated as if its accuracy was 0.2800000000000000mm. These numbers and formulas lead to the quantity "Scale Demoninator" used in the XML examples in the WMTS standard, as follows:

$$\frac{1}{\text{Scale Denominator}} = \frac{\text{meters/pixel on device}}{\text{meters/pixel on x- or y- axis}}$$

$$= \frac{0.00028}{\frac{32\,881\,518.700504}{2^{n+8}}}$$

$$= \frac{0.00028 * 2^{n+8}}{32881518.700504}$$

Therefore:

$$\text{Scale Denominator} = \frac{32881518.700504}{0.00028 * 2^{n+8}}$$

Example 1. At zoom level $n = 5$, the scale denominator is 14335204.51158959. Multiplying this by the device's nominal pixel size of 0.28mm gives 4013.857263245084 meters/pixel.

The above discussion of scale was confined entirely to the pixel size *on the device,* to the pixel's extent on the *UPS projection plane,* and to the ratio between these. No mention of latitude was necessary. To relate the pixel size to a length *on the Earth* (i.e the WGS 84 ellipsoid model of the Earth), where latitude is a dependency, see Table (TBD) or use the fact that Table 4 of **NGA.SIG.0014_1.0_PROJRAS** is relatively correct between latitudes. Here are some examples:

Example 2. At zoom level $n = 5$, the ratio, meters(map)/pixel is 4013.857263245084 as explained in Example 1. At the Pole, the ratio, meters(Earth)/pixel, is this number adjusted upwards by division by the UPS scale number 0.994 (exact). The result is 4038.085777912559.

Example 3. At zoom level $n = 5$, the ratio, meters(Earth)/pixel, for latitude 60°N is 3767.81. This number can be computed as the value at the Pole (see Example 2) times the ratio $\frac{Tsble4at60}{Table4at90} = \frac{4214.27}{4516.57} = 0.933069$.

B.5 NATO Compatible well known scale set definition.

This well-known scale set has been defined to be compatible with NATO systems using the **WGS_1984_World_Mercator** map projection. It consists of 29 levels made from a Renard series of five scale denominators per decade (R5). This may be extended to larger scales following the same pattern if required. The tiling scheme has its origin at -20050000 m east and 30200000 m north (approximate longitude 180° west and latitude 89° north) and is designed to be used for 256 x 256 pixel tiles. Table X summarises the scale denominator and approximate resolution for each scale level. The exact resolution can be calculated from the scale denominator for a screen resolution of 96 pixels per US Survey inch. The XML encoding is also shown in this ANNEX.

Table 14: NATO Compatible well known scale set

CRS	Level ID	Scale Denominator	Approximate Resolution
EPSG:3395 World Mercator **OGC Well know text description for 3395:** *PROJCS["WGS_1984_World_Mercator",GEOGCS["GCS_WGS_1984",DATUM["D_WGS_1984",SPHEROID["WGS_1984",6378137.0,298.257223563]],PRIMEM["Greenwich",0.0],UNIT["Degree",0.0174532925199433]],PROJECTION["Mercator"],PARAMETER["False_Easting",0.0],PARAMETER["False_Northing",0.0],PARAMETER["Central_Meridian",0.0],PARAMETER["Standard_Parallel_1",0.0],UNIT["Meter",1.0],AUTHORITY["EPSG",3395]]*	0	630000000	166687.833
	1	400000000	105833.545
	2	250000000	66145.9656
	3	160000000	42333.418
	4	100000000	26458.3863
	5	63000000	16668.7833
	6	40000000	10583.3545
	7	25000000	6614.59656
	8	16000000	4233.3418
	9	10000000	2645.83863
	10	6300000	1666.87833
	11	4000000	1058.33545
	12	2500000	661.459656
	13	1600000	423.33418
	14	1000000	264.583863
	15	630000	166.687833
	16	400000	105.833545
	17	250000	66.1459656
	18	160000	42.333418
	19	100000	26.4583863
	20	63000	16.6687833
	21	40000	10.5833545
	22	25000	6.61459656
	23	16000	4.2333418
	24	10000	2.64583863
	25	6300	1.66687833
	26	4000	1.05833545
	27	2500	0.66145966
	28	1600	0.42333418
	29	1000	0.26458386

XML Descriptions

WGS_1984


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WMTS_EPSG_3395

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WMTS_EPSG_4326

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WMTS_EPSG_5042

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Annex C

DGIM groups and subgroups in baseline 2016-2.0

This annex shows the groups and subgroups in the DGFCD, as in DGIF baseline 2016-2.0. Each group, and each subgroup, is uniquely identified by either one of these two fields: alphaCode (*name)* and 531-Code (*alias)*.
Each subgroup belongs to exactly one group. One group (Abstract – G22) is not related to any subgroup.

Group G01: **IndustriesServices**

- Subgroup SG0101: Extraction
- Subgroup SG0102: FabricationProcessing
- Subgroup SG0103: Agriculture
- Subgroup SG0104: PowerSupplies
- Subgroup SG0105: Communication
- Subgroup SG0106: AssociatedSupportStruct
- Subgroup SG0107: StorageProvision
- Subgroup SG0108: WasteManagement

Group G02: **SocioEconomicGeography**

- Subgroup SG0201: Habitats
- Subgroup SG0202: SettlementsAssociated
- Subgroup SG0203: EconomicCommercial
- Subgroup SG0204: Leisure
- Subgroup SG0205: PoliticsAdministration
- Subgroup SG0206: SciencesEducation
- Subgroup SG0207: CulturalContext

Group G03: **Transportation**

- Subgroup SG0301: Railways
- Subgroup SG0302: RoadsTracks
- Subgroup SG0303: GuidedTransportation
- Subgroup SG0304: WaterBorneTransportation
- Subgroup SG0305: AirTransportation
- Subgroup SG0306: Restrictions
- Subgroup SG0307: CrossingsLinks
- Subgroup SG0308: TransportationAssociated
- Subgroup SG0309: SpaceTransportation
- Subgroup SG0310: DistributionNetworks

Group G04: **HydrographyOceanography**

- Subgroup SG0401: CoastalLittoralZones
- Subgroup SG0402: PortsHarbours
- Subgroup SG0403: Depths

- Subgroup SG0404: NatureOfSeabed
- Subgroup SG0405: OffshoreConstructInstall
- Subgroup SG0406: TidesCurrents
- Subgroup SG0407: RoutesNavigation
- Subgroup SG0408: HazardsObstructions
- Subgroup SG0409: SeaIce
- Subgroup SG0410: RegulatedRestrictedZones
- Subgroup SG0411: InlandWaters
- Subgroup SG0412: PhysicsOfWater

Group G05: **Physiography**

- Subgroup SG0501: Hypsography
- Subgroup SG0502: Geomorphology
- Subgroup SG0503: Rocks
- Subgroup SG0504: Soils
- Subgroup SG0505: NaturalResources
- Subgroup SG0506: SeismologyVolcanology
- Subgroup SG0507: Glaciers
- Subgroup SG0508: Anomalies
- Subgroup SG0509: GlobalEarthCover

Group G06: **Biota**

- Subgroup SG0601: CultivatedLand
- Subgroup SG0602: Rangeland
- Subgroup SG0603: Woodland
- Subgroup SG0604: Wetland
- Subgroup SG0605: AridAreas
- Subgroup SG0606: RegionsRestrictedAreas
- Subgroup SG0607: Fauna
- Subgroup SG0608: Flora

Group G07: **Demarcation**

- Subgroup SG0701: BoundariesLimits
- Subgroup SG0702: LandSurveyRealEstate

Group G08: **Aeronautical**

- Subgroup SG0801: AerodromesMoveSurfLighting
- Subgroup SG0802: AirspaceRoutes
- Subgroup SG0803: NavaidsLandAidsPointsObst
- Subgroup SG0804: ServicesOrgsTimetables
- Subgroup SG0805: TerminalProcedures

Group G09: **Military**

- Subgroup SG0901: DefensiveOperationalStruct
- Subgroup SG0902: RestrictedAreasBoundaries
- Subgroup SG0903: OperationsEvents

Group G12: **WeatherClimate**

- Subgroup SG1001: WeatherPhenomena
- Subgroup SG1002: ClimateConditions
- Subgroup SG1003: ClimateZonesRegions

Group G11: **Characteristics**

- Subgroup SG2001: Position
- Subgroup SG2002: MeasurableValues
- Subgroup SG2003: DatesDurations
- Subgroup SG2004: Appearance
- Subgroup SG2005: FunctionStatus

Group G20: **NamesDesignations**

- Subgroup SG2101: Names
- Subgroup SG2102: Designations

Group G21: **MetadataReferences**

- Subgroup SG2201: Annotation
- Subgroup SG2202: Portrayal
- Subgroup SG2203: DateCurrency
- Subgroup SG2204: Quality
- Subgroup SG2205: ReferencesSources
- Subgroup SG2206: SystemsOfClassification

Group G22: **Abstract**