



OGC TWO DIMENSIONAL TILE MATRIX SET AND TILE SET METADATA

STANDARD
Implementation

APPROVED

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ABSTRACT

The OGC Two Dimensional Tile Matrix Set and Tile Set Metadata Standard defines the rules and requirements for a tile matrix set as a way to index space based on a set of regular grids defining a domain (tile matrix) for a limited list of scales in a Coordinate Reference System (CRS) as defined in OGC 18-005r5 Abstract Specification Topic 2: Referencing by Coordinates. This content was initially included in the OGC 07-057r7 OpenGIS Web Map Tile Service Implementation Standard (WMTS) and was separated out into the OGC 17-083r2 OGC Two Dimensional Tile Matrix Set Standard version 1.0, to support reusability in other data formats of services that need a tiling scheme. This document is a revision of the OGC 17-083r2 document and the general tile matrix set concept is inherited from it with small additions. In a tile matrix set, each tile matrix is divided into regular tiles. In a tile matrix set, a tile can be univocally identified by a tile column, a tile row, and a tile matrix identifier. The OGC Two Dimensional Tile Matrix Set and Tile Set Metadata Standard describes a data structure defining the properties of the tile matrix set in both Unified Modeling Language (UML) diagrams and in tabular form. This document also defines a new data structure, called tile set metadata, that can be used to describe a particular set of tiles following a tile matrix set. Extensible Markup Language (XML) and JavaScript Object Notation (JSON) encodings are described both for tile matrix sets and tile matrix set metadata. It includes tile matrix set limits, links to the tile matrix set, details of the original data represented by the tile set and a nice point of origin to start exploring the tile set. Finally, the document offers practical examples of tile matrix sets both for common global projections and for specific regions.

KEYWORDS

The following are keywords to be used by search engines and document catalogues.

ogcdoc, OGC document, tiles, maps, tile matrix set

PREFACE

In 2007 the OGC approved and released the Web Map Tile Service Standard OGC 07-057r7 (WMTS). WMTS defines the concept of a “tile matrix set”. Over time, other OGC Standards with requirements for “tiles” or tiled structures needed to use the same definition. Unfortunately, other OGC Standards could not use the tile matrix set definition directly because the definition was formally linked to the tile service. This revision uncouples the concept of a tile matrix set from the WMTS standard so that other standards can reference the concept directly. This version of the standard also provides an informative list of commonly used tile matrix sets and ensures consistency with the OGC 19-014r3 OGC Abstract Specification Topic 22 – Core Tiling Conceptual and Logical Models for 2D Euclidean Space. This document is anticipated to impact and inform future revisions of other OGC Standards such as GeoPackage and CDB and be used in future formats and services needing tiles for storage or parallel processing.

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SECURITY CONSIDERATIONS

The correct definition of a tile matrix set and the availability of tile set metadata are crucial to be able to correctly geo-reference a tile. The use of the wrong tile matrix set could result in incorrect geo-referencing of the tiles and the features represented in those tiles. In an emergency situation, such incorrect referencing could result in sending first responders to the wrong location.

In a normal service interaction, the client requests the tile matrix set once and requests one or more tiles afterwards. The client needs to ensure that the tile matrix set definition has not been tampered with and corresponds to the correct tile matrix set. In practice this means that the client and server must use a mechanism to ensure that the service is really what it claims to be and that the message that travels from the server to the client has not been altered.

If a server points to a definition of a tile matrix set that is hosted elsewhere, in addition to the precautions stated above, the client must ensure that the service providing the definition of the tile matrix set is a trusted service. In addition, the synchronization of the tiles and the tile matrix set definition need to be ensured, guaranteeing that the tile matrix set definition has not been updated afterwards without the tile service knowing it.

SUBMITTING ORGANIZATIONS

The following organizations submitted this Document to the Open Geospatial Consortium (OGC):

- Universitat Autonoma de Barcelona (UAB-CREAF)
- Image Matters LLC
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- US Army Geospatial Center

SUBMITTERS

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SCOPE

SCOPE

This OGC Two Dimensional Tile Matrix Set (TMS) and Tile Set Metadata Standard specifies the concepts of a tile matrix set and tile set metadata, prioritizing their implementation in two-dimensional (2D) space. There are also some considerations on how to extend the TMS concept to multi-dimensional (nD) space with more than 2 dimensions. This Standard also provides both Extensible Markup Language (XML) and JavaScript Object Notation (JSON) encodings.

The Tile Matrix Set concept, initially developed as part of the OGC Web Map Tile Service (WMTS) 1.0 Standard, is now provided as an independent standard that can be referenced by other standards such as OGC API – Tiles, OGC GeoPackage, OGC CDB, or the Natural Resources Canada (NRCan)-promoted specification *Map Markup Language* (*MapML*). In addition, the OGC Two Dimensional Tile Matrix Set (TMS) and Tile Set Metadata Standard ensures that the TMS concept can be used to structure both gridded as well as vector data in a tiled format.

This Standard has been developed as an independent and reusable standard. However, it has been developed in parallel with the OGC API – Tiles Standard and to serve its needs. The OGC API family of standards are being developed to make it easy for anyone to provide geospatial data to the web. The OGC API Standards define resource-centric APIs that take advantage of modern web development practices (mainly API definition documents and JSON encodings). Those Standards can be considered and are being constructed as “building blocks” that can be used to assemble OGC APIs for accessing tiles over the web. Throughout this Standard, some OGC API specific comments are found, that can be ignored for other applications.

This Standard also contains an informative annex for Common TileMatrixSet definitions (Informative) with a library of proposed tile matrix set definitions for Mercator, Transverse Mercator, Polar Stereographic, Lambert Azimuthal Equal Area, and Lambert Conformal Conic projections. An additional annex for Variable width TileMatrixSet definitions (Informative) provides tile matrix set definitions, utilizing the variable width capabilities of this standard, which allows for roughly approximate equal area tiles for Plate Carrée projections.

Global identifiers for the Tile Matrix Sets defined in these annexes are registered with the [OGC Naming Authority](#) and listed in the [Tile Matrix Set Register](#).

Tile Set Metadata provides information about the intended use of a Tile Set as well as the origin, access constraints, tiling scheme, layers and feature properties contained within. A tile set is a series of tiles containing data and following a common tiling scheme. Tile Set Metadata is intended to facilitate retrieval of tile sets and describes the major characteristics of tile sets without either accessing the tiles or the content within a tile. The concept of Tile Set Metadata was initially developed in phase two of the OGC Vector Tiles Pilot (<https://www.ogc.org/vectortiles2>) and the results documented in OGC 19-082r1 OGC Vector Tiles Pilot 2: Tile Set Metadata Engineering Report.

NOTE: A previous version of this standard had a JSON-LD encoding of the classes presented in Clause 6.2. This encoding was abandoned and not included in this version as no interest was detected.

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CONFORMANCE

CONFORMANCE

This standard defines the concept of tile matrix set, tile matrix set limits and tile set metadata.

Requirements for the following standardization target types are defined.

- TileMatrixSet: This abstract class defines a data model for tile matrix sets [<http://www.opengis.net/spec/tms/2.0/req/tilematrixset>]. This abstract class has a single conformance class: [<http://www.opengis.net/spec/tms/2.0/conf/tilematrixset>]. The target is a service or an encoding needing to define TileMatrixSet (e.g., a future version of WMTS service metadata or an OGC API – Tiles implementation).
- VariableMatrixWidth: This abstract class defines an extension of tile matrix sets for variable width [<http://www.opengis.net/spec/tms/2.0/req/variablematrixwidth>]. This abstract class has a single conformance class: [<http://www.opengis.net/spec/tms/2.0/conf/variablematrixwidth>]. The target is a service or an encoding needing to define a TileMatrixSet with variable width.
- TileMatrixSetLimits: This abstract class defines a data model for tile matrix set limits [<http://www.opengis.net/spec/tms/2.0/req/tilematrixsetlimits>]. This abstract class has a single conformance class: [<http://www.opengis.net/spec/tms/2.0/conf/tilematrixsetlimits>]. The target is a service, a client, or an encoding needing to define TileMatrixSetLimits (e.g., a future version of WMTS service metadata or an OGC API – Tiles implementation).
- TileSetMetadata: This abstract class defines a data model for tile set metadata in [<http://www.opengis.net/spec/tms/2.0/req/tilesetmetadata>]. This abstract class has a single conformance class: [<http://www.opengis.net/spec/tms/2.0/conf/tilesetmetadata>]. The target is a service, a client, or an encoding needing to declare conformity to a TileMatrixSet or/and a TileMatrixSetLimits (e.g., a future version of WMTS service metadata or an OGC API – Tiles implementation).

NOTE 1: TileSetMetadata in this standard replaces and extends TileMatrixSetLink in the version 1.0

- XMLTileMatrixSet: This class defines an encoding in XML for tile matrix sets [<http://www.opengis.net/spec/tms/2.0/req/xml-tilematrixset>]. This class has a single conformance class: [<http://www.opengis.net/spec/tms/2.0/conf/xml-tilematrixset>]. The target is a service, a client, or an encoding needing to define a TileMatrixSet in XML (e.g., a future version of WMTS service metadata).
- XMLVariableMatrixWidth: This class defines an encoding in XML for variable width tile matrix sets [<http://www.opengis.net/spec/tms/2.0/req/xml-variablematrixwidth>]. This class has a single conformance class: [<http://www.opengis.net/spec/tms/2.0/conf/xml-variablematrixwidth>]. The target is a service, a client, or an encoding needing to define a TileMatrixSet with variable width in XML.
- XMLTileMatrixSetLimits: This class defines an encoding in XML for tile matrix set limits in [<http://www.opengis.net/spec/tms/2.0/req/xml-tilematrixsetlimits>]. This class has a single conformance class: [<http://www.opengis.net/spec/tms/2.0/conf/xml-tilematrixsetlimits>].

[tilematrixsetlimits](#)]. The target is a service, a client, or an encoding needing to define a TileMatrixSetLimits in XML (e.g., a future version of WMTS service metadata or an OGC API – Tiles implementation).

- XMLTileSetMetadata: This class defines an encoding in XML for tile set metadata [<http://www.opengis.net/spec/tms/2.0/req/xml-tilesetmetadata>]. This class has a single conformance class: [<http://www.opengis.net/spec/tms/2.0/conf/xml-tilesetmetadata>]. The target is a service, a client or an encoding needing to declare conformity to a TileMatrixSet or/and a TileMatrixSetLimits using an XML encoding (e.g., a future version of WMTS service metadata).

NOTE 2: XMLTileSetMetadata in this standard replaces and extends XMLTileMatrixSetLink2d in the version 1.0

- JSONTileMatrixSet: This class defines an encoding in JSON for tile matrix sets [<http://www.opengis.net/spec/tms/2.0/req/json-tilematrixset>]. This class has a single conformance class: [<http://www.opengis.net/spec/tms/2.0/conf/json-tilematrixset>]. The target is a service, a client, or an encoding needing to define a TileMatrixSet in JSON (e.g., an OGC API – Tiles implementation).
- JSONVariableMatrixWidth: This class defines an encoding in JSON for variable width tile matrix sets [<http://www.opengis.net/spec/tms/2.0/req/json-variablematrixwidth>]. This class has a single conformance class: [<http://www.opengis.net/spec/tms/2.0/conf/json-variablematrixwidth>]. The target is a service, a client, or an encoding needing to define a TileMatrixSet with variable width in JSON.
- JSONTileMatrixSetLimits: This class defines an encoding in JSON for tile matrix set limits in [<http://www.opengis.net/spec/tms/2.0/req/json-tilematrixsetlimits>]. This class has a single conformance class: [<http://www.opengis.net/spec/tms/2.0/conf/json-tilematrixsetlimits>]. The target is a service, a client ,or an encoding needing to define a TileMatrixSet in JSON (e.g., an OGC API – Tiles implementation).
- JSONTileSetMetadata: This class defines an encoding in JSON for tile set metadata in [<http://www.opengis.net/spec/tms/2.0/req/json-tilesetmetadata>]. This class has a single conformance class: [<http://www.opengis.net/spec/tms/2.0/conf/json-tilesetmetadata>]. The target is a service, a client, or an encoding needing to declare conformity to a TileMatrixSet or/and a TileMatrixSetLimits using a JSON encoding (e.g., an OGC API – Tiles implementation).

NOTE 3: JSONTileSetMetadata in this standard replaces and extends JSONTileMatrixSetLink2d in the version 1.0

Conformance with this standard shall be verified using all the relevant tests specified in Conformance Class Abstract Test Suite (Normative) (normative) of this document. The framework, concepts, and methodology for testing, and the criteria to be achieved to claim conformance are specified in the [OGC Compliance Testing Policies and Procedures](#) and the OGC Compliance Testing web site¹.

¹<https://www.ogc.org/compliance>

All requirements-classes and conformance-classes described in this document are owned by the standard(s) identified.

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NORMATIVE REFERENCES

NORMATIVE REFERENCES

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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Peter Baumann, Eric Hirschorn, Joan Masó: OGC 09-146r6, *OGC Coverage Implementation Schema*. Open Geospatial Consortium (2017). <https://docs.ogc.org/is/09-146r6/09-146r6.html>.

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Tim Wilson: OGC 07-147r2, OGC KML. Open Geospatial Consortium (2008). https://portal.ogc.org/files/?artifact_id=27810.

ISO/IEC: ISO/IEC 15444-1, *Information technology – JPEG 2000 image coding system – Part 1: Core coding system*. International Organization for Standardization, International Electrotechnical Commission, Geneva <https://www.iso.org/standard/78321.html>.

ISO/IEC: ISO/IEC 15444-9, *Information technology – JPEG 2000 image coding system: Interactivity tools, APIs and protocols – Part 9*. International Organization for Standardization, International Electrotechnical Commission, Geneva <https://www.iso.org/standard/39413.html>.

ISO: ISO 19107, *Geographic information – Spatial schema*. International Organization for Standardization, Geneva <https://www.iso.org/standard/66175.html>.

ISO: ISO 19111, *Geographic information – Referencing by coordinates*. International Organization for Standardization, Geneva <https://www.iso.org/standard/74039.html>.

ISO: ISO 19115-1, *Geographic information – Metadata – Part 1: Fundamentals*. International Organization for Standardization, Geneva <https://www.iso.org/standard/53798.html>.

4

TERMS AND DEFINITIONS

TERMS AND DEFINITIONS

This document uses the terms defined in OGC 06-121r9, Clause 5.3, 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 standard.

This document also uses terms defined in the OGC Standard for Modular specifications ([OGC 08-131r3](#)), also known as the 'ModSpec'. The definitions of terms such as standard, specification, requirement, and conformance test are provided in the ModSpec.

For the purposes of this Standard, the following additional terms and definitions apply:

4.1. cell

minimum geometrical spaces delimited by the grid lines of a regular grid.

Note 1 to entry: in 2D spaces, cells are often referred as pixels.

Note 2 to entry: In this standard, the term *pixel* is reserved to the individual elements of a visualization device. Tiles are composed by regular grid cells that can be made partially coincident with the pixels of a visualization device for display purposes.

4.2. coordinate reference system

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

[**SOURCE:** ISO 19111]

4.3. coordinate system

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

[**SOURCE:** ISO 19111]

4.4. domain

well-defined set

Note 1 to entry: A mathematical function may be defined on this set, i.e. in a function $f : A \rightarrow B$, A is the domain of the function f .

[SOURCE: ISO 19103]

4.5. grid

network composed of two or more sets of curves in which the members of each set intersect the members of the other sets in an algorithmic way

Note 1 to entry: The curves partition a space into grid cells.

Note 2 to entry: A grid can be used to define a tessellation of the space.

[SOURCE: ISO 19123]

4.6. range set

set of all values a function f can take as its arguments vary over its domain

[SOURCE: OGC 07-036]

4.7. raster tile

tile that contains information in a gridded form. Commonly the values of the grid represent colors of each cell in the grid for immediate pictorial representation on visualization devices, but can also be coverage subsets.

Note 1 to entry: This concept is used in this standard as a contraposition of “vector tiles”. Many of the existing implementations of WMTS 1.0 produce “raster tiles”.

4.8. regular grid

grid whose grid lines have a constant distance along each grid axis

Note 1 to entry: A regular grid can be used to define a regular tessellation of the space.

[SOURCE: OGC 09-146r6]

4.9. space partitioning

process of dividing a geometric space (usually a Euclidean space) into two or more disjoint subsets (see also partition of a set). Space partitioning divides a space into non-overlapping regions. Any point in the space can then be identified to lie in exactly one of the regions

[SOURCE: OGC 19-014r3]

4.10. square

regular quadrilateral with four equal sides and four 90 degree angles

[SOURCE: OGC 19-014r3]

4.11. tessellation

partitioning of a space into a set of conterminous subspaces having the same dimension as the space being partitioned

Note 1 to entry: A tessellation composed of congruent regular polygons or polyhedra is a regular tessellation. One composed of regular, but non-congruent polygons or polyhedra is a semi-regular tessellation. Otherwise the tessellation is irregular.

Note 2 to entry: The expression “same dimension” should be interpreted as “same dimensionality”

[SOURCE: ISO 19123]

4.12. tile

geometric shape with known properties that may or may not be the result of a tiling (tessellation) process. A tile consists of a single connected “piece” without “holes” or “lines” (topological disc).

In the context of a 2D *tile matrix*, a *tile* is one of the rectangular regions of space, which can be uniquely identified by an integer row and column, making up the tile matrix.

In the context of a geospatial data *tile set*, a *tile* contains data for such a partition of space as part of an overall set of tiles for that tiled geospatial data.

Note 1 to entry: From OGC 19-014r3: Core Tiling Conceptual and Logical Models for 2D Euclidean Space

Note 2 to entry: Tiles are useful to efficiently request, transfer, cache, display, store and process geospatial data for a specific resolution and area of interest, providing deterministic performance and scalability for arbitrarily large datasets.

Note 3 to entry: Tiles can contain a variety of data types, such as grid-based pictorial representations (map tiles), coverage subsets (coverage tiles), or feature-based representations (vector tiles).

4.13. tile matrix

tiling grid in a given 2D coordinate reference system, associated to a specific scale and partitioning space into regular conterminous *tiles*, each of which being assigned a unique identifier

Note 1 to entry: Each tile of a tile matrix is uniquely identifiable by a row and a column integer indices. The number of rows is referred to as the *matrix height*, while the maximum number of columns is referred to as the *matrix width* (the number of columns can vary for different rows in *variable width tile matrices*).

4.14. tile matrix set

tiling scheme consisting of a set of *tile matrices* defined at different scales covering approximately the same area and having a common coordinate reference system.

4.15. tile indexing scheme

scheme allowing to uniquely reference a *tile* in a *tiling scheme* by the use of a unique identifier (or set of identifiers), and reversely, which unique identifier (or unique set of identifiers) corresponds to a space satisfying the geometric properties of a specific tile

Note 1 to entry: Adapted from the indexing aspect of the *tile scheme* definition of the OGC 19-014r3: Core Tiling Conceptual and Logical Models for 2D Euclidean Space

4.16. tile set

a set of *tiles* resulting from tiling data according to a particular *tiling scheme*

Note 1 to entry: From OGC 19-014r3: Core Tiling Conceptual and Logical Models for 2D Euclidean Space, but adapted to clarify that in the context of this document, a tile set refers specifically to a set of tiles containing data and following a common tiling scheme.

4.17. tiling scheme

scheme that defines how space is partitioned into individual *tiles*, potentially featuring multiple levels of detail (each tiling at a different granularity to reflect a different resolution or scale)

A tiling scheme defines the spatial reference system and the geometric properties of each tile defined by the scheme. Those properties include which space each tile occupies, i.e. its extent, as well as a tile coordinate origin if a particular corner of origin convention is established.

Note 1 to entry: A tiling scheme can be defined on top of a CRS as well as other spatial reference systems such as DGGS and other organizations including irregular ones. In this document, only tiling schemes based on CRSs are supported.

Note 2 to entry: From the *tile set scheme* and *tile scheme* definitions of OGC 19-014r3: Core Tiling Conceptual and Logical Models for 2D Euclidean Space, adapted to reflect the fact that a *tiling scheme* already imparts individual tiles with an origin and an extent

4.18. tile set metadata

additional metadata beyond the common properties defining the *tile set*. Such metadata could be an abstract, the owner, the author, or other common metadata.

metadata describing common properties defining a *tile set*, layers and styles used to produce the tile set, the limits of the tile matrix with actual data and common metadata such as abstract, owner, author, etc.

[SOURCE: OGC 19-014r3]

4.19. vector tile

tile that contains vector information that has been generalized (simplified) at the tile scale resolution and clipped by the tile boundaries.

Note 1 to entry: The expression “vector tile” has stirred some controversy in the OGC. Actually, the OGC uses geometrical features to refer to things that are commonly known as vectors in many GIS tools. However, in this case, this standard recognizes the ubiquity of the expression in the sector and assumes that the concept is not associated to any particular technology or commercial brand.

4.20. well-known scale set

well-known combination of a coordinate reference system and a set of scales that a tile matrix set declares support for

5

CONVENTIONS

CONVENTIONS

This section provides details and examples for any conventions used in the document.

5.1. Abbreviated terms

| | |
|------|---|
| CDB | Abbreviated reference for the OGC CDB Standard. |
| CRS | Coordinate Reference System |
| DGGS | Discrete Global Grid System |
| EPSG | European Petroleum Survey Group |
| JSON | JavaScript Object Notation |
| TMS | Tile Matrix Set |
| WMTS | Web Map Tile Service |
| XML | eXtensible Markup Language |
| 2D | 2-dimensional |
| 3D | 3-dimensional |

5.2. Identifiers

The normative provisions in this Standard are denoted by the URI

<http://www.opengis.net/spec/tms/2.0>

All requirements and conformance tests that appear in this document are denoted by partial URIs which are relative to this base URI.

5.3. Common Classes

The following classes are extracted from the OGC 06-121r9 OWS Common Standard. As such, the data structures presented in this Standard become independent from OWS Common Standard and can be used independently.

5.3.1. Multilingual text encoding

Some text parameters specified with the data type `CharacterString` in UML are intended to have human-readable values. However not all humans can understand the same spoken languages. This data class is mapped to XML or JSON encodings afterwards.

The specified approach for allowing the language of a text value to be explicitly stated is indicated by the UML class diagram in Figure 1.



Figure 1 – LanguageString UML model

The `value` parameter specifies the human-language string, and the `lang` parameter specifies the language (in IETF RFC 4646 syntax) of the string. If a `lang` parameter is not present, then no language has been specified for the string unless specified by another means.

In the case that multiple languages are necessary in a single document instance, the element that is of the `LanguageString` type should be a list with one entry for each `lang` code.

NOTE: OGC APIs will use the language negotiation with HTTP headers. In this situation, it is expected that elements defined as a list of `LanguageString` will default into a single `CharacterString` that in JSON will default into a string data type. This does not preclude that in other environments the JSON encodings for language string can implement the `LanguageString`. In practice this means that a JSON schema for a `LanguageString` element should support both string and language string types.

5.3.2. Description, Title and Keywords

A basic set of data description parameters that include a human-readable title, description, and keywords are widely used in this Standard and defined here as a UML class diagram.



Figure 2 – Description Title Keywords UML model

Table 1 – Parts of Description Title Keyword data elements

| NAMES | DEFINITION | DATA TYPE AND VALUES | MULTIPLICITY AND USE |
|-------------|---|--------------------------------|---|
| title | Title of a tile matrix set, normally used for display to a human | LanguageString data structure | Zero or more (optional) Include when available and useful Include one for each language represented |
| description | Brief narrative description of a tile matrix set, normally available for display to a human | LanguageString data structure | Zero or more (optional) Include when available and useful Include one for each language represented |
| keywords | Unordered list of one or more keywords | MD_Keywords class in ISO 19115 | Zero or more (optional) One for each keyword authority used (one for each 'type' value) |

The Keywords element is defined according to the MD_Keywords class that is specified in ISO 19115-1 and has a list of keywords of the same 'type' specified in the optional 'type' element.

Table 2 – Parts of Keyword data elements

| NAMES | DEFINITION | DATA TYPE AND VALUES | MULTIPLICITY AND USE |
|---------|---|--|------------------------|
| keyword | Unordered list of one or more commonly used or formalized word(s) or phrase(s) used to describe a dataset | LanguageString data structure | One or more (optional) |
| type | Type of the keyword | CodeType, as adaptation of MD_Identifier class ISO 19115 | Zero or one (optional) |

NOTE: OGC APIs will use language negotiation with HTTP headers. In this situation, it is expected that elements defined as a list of LanguageString will default into a single CharacterString that in JSON will default into a string data type. In JSON encodings, namespaces or codespaces (optional in the model) are not considered. This results in a simplification of the keywords in the JSON encoding to a simple array of strings.

5.3.3. BoundingBox

A (basic) bounding box is one type of bounding box that is used in this Standard. The Bounding box data structure is specified in the following UML model and table.

The BoundingBox class describes a Minimum Bounding Rectangle (MBR) surrounding a feature (in the broader sense), in the supported CRS.

A 2DBoundingBox is another type of bounding box. This type is simplified from the basic BoundingBox data type for use only with the 2D geographic CRS. This is useful for specifying the extent 2D part of tile matrix set.

A WGS84BoundingBox is another type of bounding box. This type is simplified from the basic BoundingBox data type for use only with the 2D geographic CRS which uses the WGS 84 geodetic datum, where longitude precedes latitude and both are recorded in decimal degrees.



Figure 3 – BoundingBox UML model

Table 3 – Parts of BoundingBox data structure

| NAMES | DEFINITION | DATA TYPE AND VALUES | MULTIPLICITY AND USE |
|-------------|--|--|---|
| lowerLeft | Coordinates of bounding box corner at which the value of each coordinate normally is the algebraic minimum within this bounding box ^a | Ordered sequence of double values ^b | One (mandatory) |
| upperRight | Coordinates of bounding box corner at which the value of each coordinate normally is the algebraic maximum within this bounding box ^a | Ordered sequence of double values ^b | One (mandatory) |
| CRS | Reference or a definition of the CRS used by the lowerRight and upperRight coordinates | CRSType | Zero or one (optional) Include unless referenced elsewhere |
| orderedAxis | Ordered list of names of the dimensions defined in the CRS | Ordered sequence of strings | Zero or one (optional) ^c |

^a Values other than the minimum and maximum may be used as discussed below.

^b The number of axes included, and the order of these axes, as specified by the referenced CRS.

^c The number of axes and names is specified by the referenced CRS definition, but may also be specified here for convenience. In particular, it makes the axis order more visible.

If the referenced CRS uses an Ellipsoidal, Spherical, Polar, or Cylindrical coordinate system, the bounding box contents defined will not always specify the MINIMUM rectangular BOUNDING region (as those terms are specified in OGC Abstract Specification Topic 2). Specifically, this bounding box will not specify the minimum rectangular bounding region surrounding a geometry in which the set of points spans the value discontinuity in an angular coordinate axis. Such axes include the longitude and latitude of Ellipsoidal and Spherical coordinate systems. That geometry could lie within a small region on the surface of the ellipsoid or sphere.

Theoretically, there are cases where defining a bounding box could be problematic or impossible, such as angular axis of an Ellipsoidal, Spherical, Polar, or Cylindrical coordinate system. However, tiles need to be circumscribed to real coordinates and will deliberately avoid regions of the space where coordinates go to infinite or cannot be defined. For example, the WorldMercatorWGS84Quad tile matrix set (based on a cylindrical projection) should not be used close to the poles. Since tiles are conterminous, it is always possible to define a bounding box that includes them all.

5.3.4. CRSType

In this version of the standard, the possibility to define a CRS using a full description in addition to a reference to an external CRS catalogue is introduced. For backwards compatibility, CRSType still defaults to a URI but is extended to a union of three possibilities (URI, WKT2 CRS, or ISO 19115 MD_ReferenceSystem).

Table 4 – Parts of CRSType data structure

| NAMES | DEFINITION | DATA TYPE AND VALUES |
|-----------------|---|----------------------|
| uri | A reference to a CRS. Typically a EPSG CRS reference | URI |
| wkt | A definition for CRS that uses Well-known text representation of coordinate reference systems Version 2.0 | Any |
| referenceSystem | A reference system data structure as defined in the MD_ReferenceSystem of the ISO 19115 | MD_ReferenceSystem |

5.3.5. WebLink

Many recent standards emphasize the usefulness of links as a way to relate a data structure instance to other data structures and make navigation through resources possible. Essential links are made explicit in the data structures of this document (recognizable by a URI data type) but other links can be added as needed for convenience when a WebLink is available. The data structure defined here allows the addition of other links. The definition is based on the web linking defined in the IETF RFC 8288 and the XML serialization present in IETF RFC 4287, Section 4.2.7 and in the JSON serialization found in this IETF draft: <https://tools.ietf.org/id/draft-pot-json-link-01.html>

NOTE: In practice, some encodings can opt to specify the essential links as part of this data structure for convenience



Figure 4 – Web link UML model

Table 5 – Parts of the WebLink data structure

| NAMES | DEFINITION | DATA TYPE AND VALUES | MULTIPLICITY AND USE |
|----------|---|---|---|
| href | Reference from this resource to a web resource | URI or a URI template | One (mandatory) |
| rel | Link relation type describing the meaning of the link. | CharacterString ^a | Zero or one (optional) |
| type | hint about the type of the representation that is expected to be returned from the href attribute | CharacterString ^b | Zero or one (optional) |
| hreflang | language of the resource pointed to by the href attribute | LanguageString data structureCharacterString ^c | Zero or one (optional) |
| title | human-readable information about the link | CharacterString ^c | Zero or one (optional) Include one for each language represented |
| length | hint about the length of the linked content in bytes | nonNegativeInteger | Zero or one (optional) |

^a It can be a name or a URI. If a name is given, implementations must consider the link relation type equivalent to the same name registered within the IANA Registry of Link Relations. The OGC Naming Authority maintains other possible values at <http://www.opengis.net/def/rel>.

^b It should be a media type format as specified in IETF RFC 6838, Section 4.2

^c As specified in IETF RFC 5646

6

TILEMATRIXSET

6.1. Overview

As stated in OGC 18-005r5 Abstract Specification Topic 2: Referencing by Coordinates, a coordinate system is a set of mathematical rules for specifying how coordinates are to be assigned to points in space. A CRS is a coordinate system that is related to the real world by a reference datum. An example of mathematical rules is the application of a sphere or an ellipsoid centered in the datum and the use of a projection to transform the sphere or the ellipsoid into a planar representation of the world. Usually, the resulting planar coordinates are expressed as real numbers that are distances to the origin of the projection. This section introduces a tile scheme called Tile Matrix Set that is defined on top of a CRS. A fundamental part of the definition of a Tile Matrix Set is the Tile Matrix.

6.1.1. Tile Matrix

A *Tile Matrix* tile set defined by a tile scheme based on a regular tessellation of a 2D planar surface that follows a regular grid coverage. For the OGC 09-146r6 CIS GeneralGridCoverage, the domain set of a grid describes the direct positions in multi-dimensional coordinate space, depending on the type of grid. In a grid-regular coverage, simple equidistant grids are established. When a grid-regular coverage is used to represent the world, the space becomes discrete in each dimension of the grid *domain range*. One possible discrete subdivision is the use of multidimensional *grid cells*. Another is to divide the domain into regular intervals that can be assigned to integer numbers that enumerate and identify *tiles*. This grid of tiles domain range can be defined by:

- a) The point of origin and corner of origin in a two-dimensional space of the bounding box of regular grid coverage (e.g., the CRS coordinates of the top left corner of the top left extreme where the integer coordinates are 0). This is the tile set origin that defines where the spatial origin reference point is for the entire tile set.
- b) A tile size in CRS units for each dimension of the CRS; and
- c) The size of the tile matrix in tile units (i.e., number of tiles) that closes the bounding box of the tiled space. Frequently the sizes of the two first dimensions are called *matrix width* and *matrix height*.

6.1.1.1. Tile matrix in a two-dimensional space.

Two main use cases can be defined for tiles: storage and visualization. When Tiles are rendered in visualization devices that have the space quantized in pixels characterized by a size the concept of scale emerges. Then, the tile size in CRS units of the first two spatial dimensions and the size of the visualization device pixels become related. The two spatial dimensions are aligned with the pixel axes of the device.

In raster tiles, a second regular grid that is coincident with the tile matrix but denser (with smaller cell size but an exact submultiple of that size) is defined. Each grid cell of this new higher resolution grid is called a *grid cell*. The grid cells are defined by equally dividing the original tiles into *grid cells* using the *number of rendering cells in a tile (tile width and tile height)*. In common tiled 2D visualization clients, a part of the *grid cell* is made coincident with the device pixels and this part of the grid is rendered in the device: the second grid is named here as the *extrapolated device grid*. In other words, a tile is divided in a number of cells in each dimension of the CRS in a way that creates cells that will become the exact same size of the pixels of a visualization device during visualization. The relation between both sizes is a function of the following two parameters:

- a) A scale (expressed as a scale denominator) and
- b) A grouping of *rendering pixels* in a tile forming the tile. Common grouping values are 256×256 or 512×512 . Frequently the sizes of the two first dimensions are called *tile width* and *tile height*.

NOTE 1: Commonly *tile width* and *tile height* are equal but this constraint is not imposed by this Standard.

Since services cannot predict the pixel size of the client visualization device, in this Standard, the scale denominator is defined with respect to a “standardized rendering pixel size” of $0.28 \text{ mm} \times 0.28 \text{ mm}$ (millimeters). The definition is the same as used in Web Map Service WMS 1.3.0 OGC 06-042 and in the Symbology Encoding (SE) Implementation Specification 1.1.0 OGC 05-077r4 that was later adopted by WMTS 1.0 OGC 07-057r7. Frequently, the true pixel size of the device is unknown and 0.28 mm was the actual pixel size of a common display from 2005. This value is still being used as reference, even if current display devices are built with much smaller pixel sizes.

NOTE 2: Since the 1980s, the Microsoft Windows operating system has set its default standard display pixels per inch (PPI) to 96. This value results in an approximated 0.264 mm per pixel. The similarity of this value with the actual 0.28 mm adopted in this Standard can create some confusion.

NOTE 3: Modern display devices (screens) have pixels so small that operating systems allow for defining a presentation scale factor bigger than one (e.g. 150%). In these circumstances, the actual size of the device pixels is not the same as the size used by the operating system.

Normally the *matrix width* is constant and, in this circumstance, having a single scale factor using a single standardized rendering cell size for the two dimensions results in cells that have the same size in the first two dimensions. This is commonly known as *square pixels*.

NOTE 4: The geometry above is different from WMS, which does allow non-square pixels (although many implementations fail to support non-square pixels properly).

NOTE 5: In rendered tiles, it is common that the range set represents colors of the cells and is stored in PNG or JPEG files of exactly one tile. Nevertheless, nothing prevents storing other kinds of values in other formats, such as TIFF files.

Tiled vector data also make use of the *extrapolated device grid*, where the tiles are rendered for visualization purposes.

NOTE 6: Some tiled vector data expressed in formats such as GeoJSON do not make use of an *extrapolated device grid*. Other tiled formats (e.g., MBTiles) define an internal coincident grid denser than the *extrapolated device grid* and express the position using indices in this denser grid instead of coordinates.

For the case of a two-dimensional space, given the top left point of the tile matrix in CRS coordinates (`tileMatrixMinX`, `tileMatrixMaxY`), the width and height of the tile matrix in tile units (`matrixWidth`, `matrixHeight`), the *rendering cells in a tile* values (`tileWidth`, `tileHeight`), the coefficient to convert the coordinate reference system (CRS) units into meters (`metersPerUnit`), and the scale (`1:scaleDenominator`), the bottom right corner of the bounding box of a tile matrix (`tileMatrixMaxX`, `tileMatrixMinY`) can be calculated as follows:

$$\text{cellSize} = \text{scaleDenominator} \times 0.2810^{-3} / \text{metersPerUnit}(\text{crs})$$

$$\text{tileSpanX} = \text{tileWidth} \times \text{cellSize}$$

$$\text{tileSpanY} = \text{tileHeight} \times \text{cellSize}$$

$$\text{tileMatrixMaxX} = \text{tileMatrixMinX} + \text{tileSpanX} \times \text{matrixWidth}$$

$$\text{tileMatrixMinY} = \text{tileMatrixMaxY} - \text{tileSpanY} \times \text{matrixHeight}$$

NOTE 7: In a CRS with coordinates expressed in meters, `metersPerUnit(crs)` equals 1.

NOTE 8: In CRS with coordinates expressed in degrees `metersPerUnit(crs)` equals $360 / (\text{EquatorialRadius} * 2 * \text{PI})$ (360 degrees are equivalent to the `EquatorialPerimeter`). E.g for WGS84 `metersPerUnit(crs)` is 111319.4908 meters/degree.

The tile space therefore looks like this:



Figure 5 – Tile Space (the corner of origin is topLeft)

Each tile in a tile matrix is identified by its *tileCol* and *tileRow* indices that have their 0,0 origin in one of the corners of the tile matrix. When the topLeft corner is used, *tileCol* increases towards the right and *TileRow* towards the bottom, as shown in Figure 5 (bottomLeft corner can also be used as origin making *TileRow* increase towards the top). Annex I includes pseudocode that illustrates the process for obtaining the tile indices that cover a bounding box rectangle and also the computation to get the CRS coordinates that bound a tile.

NOTE 9: A tile matrix can be implemented as a set of image files (e.g., PNG or JPEG) in a file folder, each file representing a single tile

NOTE 10: Section 6 of the TIFF specification v6 defines 2D tiles in the same way that has been done in this standard. All tiles in a tile matrix can be stored in a single TIFF file. The TIFF file includes only one set conterminous tiles sharing a common single scale.

6.1.2. Tile Matrix Set

Depending on the range of scales needed to be represented in the screen of a client, a single tile matrix is impractical and might force the software to spend too much time simplifying/generalizing the dataset prior to rendering.

Commonly, several tile matrices are progressively defined covering the expected ranges of scales needed for the application. A *Tile Matrix Set* is a tile scheme composed of a collection of tile matrices, optimized for a particular scale and identified by a tile matrix identifier. Each Tile Matrix Set has an optional approximated bounding box, but each tile matrix has an exact

bounding box that is deduced indirectly from other parameters. Tile matrix bounding boxes at each scale will usually vary slightly due to their cell alignment.



Figure 6 – Tile Matrix Set representation

A Tile Matrix has a unique alphanumeric identifier in the Tile Matrix Set. Some tile-based implementations prefer to use a *zoom level* number or level of detail designation (LoD) which has the advantage of suggesting some order in the list of tile matrices. This Standard does not use the *zoom level* concept but, to ease adoption of this standard in implementations that prefer numeric zoom levels, many Tile Matrix Sets defined in Annex D use numbers as Tile Matrix identifiers. In this case, the index order in the list of tile matrices defined in a Tile Matrix Set could still be used as a *zoom level ordering* internally.

In some other standards, the tile matrix set concept is called an *image pyramid*, like in clause 11.6 of the OGC KML 2.2 OGC 07-147r2 standard. JPEG2000 (ISO/IEC 15444-1) and JPIP (ISO/IEC 15444-9) also use a similar division of the space called *resolution levels*. Nevertheless, in those cases the pyramid is self-defined starting from the more detailed tile matrix (that uses square tiles), and constructing tiles of the next scales by successively aggregating 4 tiles of the previous scale, and so on (see Figure 6), and interpolating each 4 contiguous values of the previous scale into one in the next scale. That approach involves a more rigid structure which has scales related by powers of two and tiles that perfectly overlap tiles on the inferior scale denominators. Tile Matrix Sets presented in this document are more flexible, but KML *superoverlays* or JPEG2000-based implementations can use this standard with some extra rules to describe their tile matrix sets. This document describes some tile matrix sets with scale sets related by powers of two in the Annex D.

Each of the WMTS procedure-oriented architectural style operations and resource-oriented architectural style resources are described in more detail in subsequent clauses in this standard.

NOTE: Clients and servers have to be careful when comparing floating numbers with tolerance (double precision, 16-digit numbers, have to be used).

6.1.3. Well-known scale sets

When overlaying and presenting tiles encoded in different tile matrix sets that do not have common sets of scale denominators and the same CRS in an integrated client, rescaling or re-projecting tiles to the common scale of the view might require re-sampling calculations that result in visual quality degradation.

The recommended way to prevent this problem is make use of the same global tile matrix set. For example, one of those available in Annex D. If the geographic extent of the data covers only a part of the tile matrix set area, the *tile matrix limits* element of the tileset metadata can be used to inform about these limitations.

If using the same tile matrix set is not possible, using a common CRS and a common set of scales shared by as many layers and services as possible can also be a solution. Thus, the concept of well-known scale set (WKSS) is introduced.

Note that a WKSS only defines a small subset of what is needed to completely define a Tile Matrix Set. A WKSS is an optional feature that does not replace the need to define the Tile Matrix Set and its Tile Matrices. The original purpose of WKSS is no longer necessary if services share and reference common Tile Matrix Set definitions such as the ones in Annex D.

A WKSS is a commonly used combination of a CRS and a set of scales. A tile matrix set can declare support for a WKSS set by referencing that WKSS. A client application can confirm that tiles in one tile matrix set are compatible with tiles in another tile matrix set merely by verifying that they declare a common WKSS. The informative Annex C provides several WKSSs (and others could be incorporated in the future).

A tile matrix set conforms to a particular WKSS when it uses the same CRS and defines all scale denominators ranging from some large scale denominator in the WKSS to some low scale denominator (in other words, it is not necessary to define all the lower scale denominators to conform to a WKSS).

6.1.4. Tile based coordinates in a tile matrix set

A tile in a tile-based coordinate can be referred by its tile position in the tile matrix dimensions and the tile matrix identifier in tile matrix set. In a two-dimensional space, a tile is identified by these 3 discrete index names: *tile row*, *tile column* and *tile matrix identifier*.

In raster tiles, a grid cell in the *extrapolated device grid* domain set can be identified by a set of floating point coordinates in the CRS and by one of two ways that does not present rounding issues, as follows.

- a) By the tile indices the grid cell is contained by (referred by its tile position in the tile matrix dimensions and the Tile Matrix identifier in the Tile Matrix Set) and the cell indices inside the tile (i , j , ...). In a two-dimensional space, a cell is identified by 5 discrete indices that are named: *tile row*, *tile column*, *tile matrix identifier*, i and j . This is how GetFeatureInfo works in WMTS. This set of coordinates is called “*tile coordinates*.”
- b) By the position of the cell in grid defined by the *extrapolated device grid domain* set (that starts at the top left corner of the tiled space) of the tile matrix and the identifier of the Tile Matrix in Tile Matrix Set. In a two-dimensional space, a grid cell is identified by 3 discrete indices that are named: i' , j' and *tile matrix identifier*. Note that i' and j' can be very big integer numbers and, for very detailed scale, tile matrices might require integer 64-bit notation if stored as binary numbers. This set of indices is called “*tilematrix coordinates*.”



Figure 7 – Tile coordinates (a) and Tile matrix coordinates (b) to identify grid cells

6.1.5. Variable width tile matrices

Until now, it has been assumed that *matrixWidth* is constant for all tile rows. This is common usage for projections that do not distort the Earth too much. But when using Equirectangular Plate Carrée projection (see Annex D subsection 2) the distortion increases for tiles closer to the poles. In the extreme, the upper row of the upper tile (the one representing the North Pole) contains a list of repeated values that represents almost the same position in the space. The same can be said for the lower row of the lower tile (the one representing the South Pole). When the tiles are represented in a flat projection, this is an effect that cannot be avoided, but when the data are presented in a virtual globe, the distortion results in redundant information in the poles that need to be eliminated by the client during the rendering. Compensating for distortion is better done at the server side instead.

The solution consists of reducing the number of tiles (*matrixWidth*) in the high latitude rows and generating those tiles with a compressed scale in the longitudinal dimension (see Figure 8). To

allow this solution, the tile model must be extended to specify coalescence coefficients (c) that reduce the number of tiles in the width direction by aggregating c horizontal tiles but keeping the `tileWidth` (and `tileHeight`). The coalescence coefficient is not applied next to the Equator but is used in medium and high latitudes (the higher the latitude the larger the coefficient).

Even if tiles can coalesce, this does not change the indexing or the tile matrix set that will be the same as if no coalescence has been applied. For example, if the c coefficient is 4, the `tileCol` of the first tile will be 0, the `tileCol` of the second tile will be 4, the `tileCol` of the third tile will be 8 and so on. In other words, and for the same example, `tileCol` 0, 1, 2 and 3 points to the same tile.

NOTE: This solution is necessary to still be able to define a rectangle in the space based on tile indices as we do in the Clause 8.2.1, Requirements class 7.



Figure 8 – TileMatrix with variable matrix width

6.2. TileMatrixSet Requirements Classes

6.2.1. TileMatrixSet requirements class

Requirements class `tilematrixset` establishes how to describe a TileMatrixSet for a two-dimensional tile space. The expectation is that tile matrix sets are defined once and that servers or encodings using or distributing tiles will declare the usage of a tile matrix set by linking to that tile matrix set.

REQUIREMENTS CLASS 1

Target type tile matrix sets

Dependency <http://www.opengis.net/spec/2d-tile-model/1.0/req/tile-set-scheme>

Label <http://www.opengis.net/spec/tms/2.0/req/tilematrixset>

REQUIREMENT 1

Label /req/tilematrixset/model

A tile matrix set SHALL be defined following the UML model as shown in Figure 9 and the model description in Table 6 and Table 7.

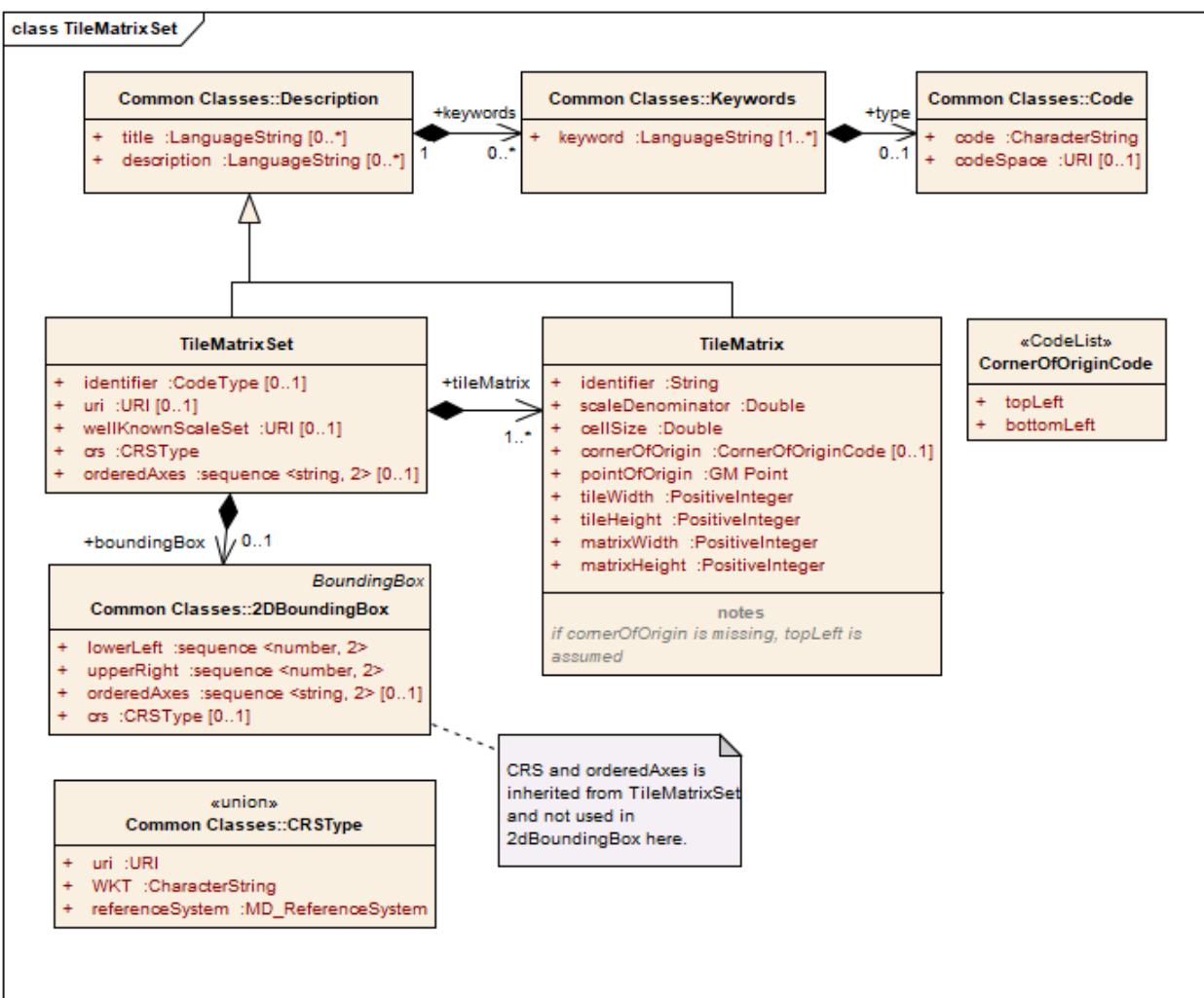


Figure 9 – TileMatrixSet UML model

Table 6 defines the structure of the TileMatrixSet.

Table 6 – Parts of TileMatrixSet data structure

| NAMES | DEFINITION | DATA TYPE AND VALUES | MULTIPLICITY AND USE |
|--------------------------|---|--|--|
| identifier | Tile matrix set identifier ^a | CodeType, as adaptation of MD_Identifier class ISO 19115 | Zero or One (optional) |
| title ^b | Title of a tile matrix set, normally used for display to a human | LanguageString data structure. See Table 1 | Zero or more (optional) Include when available and useful Include one for each language represented ^c |
| description ^b | Brief narrative description of a tile matrix set, normally available for display to a human | LanguageString data structure. See Table 1 | Zero or more (optional) Include when available and useful Include one for each language represented |
| keywords ^b | Unordered list of one or more commonly used or formalized word(s) or phrase(s) used to describe a tile matrix set | MD_Keywords class in ISO 19115. See Table 1 | Zero or more (optional) One for each keyword authority used |
| uri | Reference to an official source for a tile matrix set | URI type | Zero or One (optional) Include when an official source exists |
| crs | Coordinate Reference System (CRS) ^d | CRSType type, see Table 4 | One (mandatory) ^e |
| orderedAxes | Ordered list of names of the dimensions defined in the CRS ^f | Ordered sequence of strings | Zero or one (optional) |
| wellKnownScaleSet | Reference to a well-known scale set ^g | URI type ^h | Zero or one (optional) ⁱ |
| boundingBox | Minimum bounding rectangle surrounding the tile matrix set, in the CRS ^j | 2DBoundingBox data structure, see Table 3 | Zero or one (optional) |
| tileMatrix | Description of a scale level and its tile matrix | TileMatrix data structure. See Table 7 | One or more (mandatory) ^k |

^a TileMatrixSet identifiers SHALL be unique (different) for each TileMatrixSet of a server.

^b The multilingual scoping rules in Clause 5.3.1 apply.

^c If no Title is specified, a client may display the Identifier value instead.

- ^d The CRS of the TileSets using this TileMatrixSet should be compatible with this CRS. See Clause 6.2.1.1
- ^e In some cases where high precision is required, the use of precise realizations of the same CRS is needed or the CRS is dynamic (varies slightly with time) and needs to be accompanied by an epoch. For this data structure, a Tile MatrixSet is defined by the generic CRS name. The CRS realization and epoch used by a concrete tileset is specified in the tileset metadata. In most of the cases, tilesets sharing the same generic CRS overlap but for some high precise applications and for very fine grained scales, a client can perform run-time corrections to accurately overlay tilesets based on that information, or alternatively refuse to overlap tilesets not having the same CRS realization or epoch.
- ^f This element is not intended to overwrite the CRS axis order but to make it visible to developers by repeating information that is already contained in the CRS definition.
- ^g Some possible values are defined the in Annex C.
- ^h In WMTS 1.0 a URN was used as a reference to a well-known scale set. Later, OGC adopted HTTP URLs as URLs for references. The [OGC Naming Authority – Procedures document](#) specifies rules to transform from URN to URLs that resolve to the OGC Definitions Server (<http://www.opengis.net/def>). Implementation of on-the-fly transformations based on these rules is possible.
- ⁱ When a tile matrix set conforms to a well-known scale set, it can reference it by its URI. If used, the well-known scale set SHALL be consistent with the CRS and with the scaleDenominators of the tileMatrix parameters.
- ^j In the same CRS as the TileMatrixSet, boundingBox should be considered informative about the area covered by this TileMatrixSet. It SHOULD NOT be used to calculate the position of the tiles in the CRS space. Instead use the cornerOfOrigin and the pointOfOrigin of the corresponding TileMatrix. If data is not available for the entire tiled space, TileMatrixSetLimits will declare what tiles have data (see Clause 8.2.1, Requirements class 7).
- ^k Commonly more than one. Each tileMatrix of a tileMatrixSet SHALL have a unique (different) scaleDenominator.

In addition to a general tile matrix set description, an array of tile matrix elements is needed to define the distribution of tiles for each scale denominator.

Table 7 – Parts of TileMatrix data structure

| NAMES | DEFINITION | DATA TYPE AND VALUES | MULTIPLICITY AND USE |
|--------------------------|--|--|--|
| identifier | Tile matrix identifier ^a | ows:CodeType, as adaptation of MD_Identifier class ISO 19115 | One (mandatory) |
| title ^b | Title of a tile matrix, normally used for display to a human | LanguageString data structure. See Table 1 | Zero or more (optional) Include when available and useful Include one for each language represented ^c |
| description ^b | Brief narrative description of a tile matrix, normally | LanguageString data structure. See Table 1 | Zero or more (optional) Include when available and |

| NAMES | DEFINITION | DATA TYPE AND VALUES | MULTIPLICITY AND USE |
|----------------------------|---|---|---|
| | available for display to a human | | useful Include one for each language represented |
| keywords ^d | Unordered list of one or more commonly used or formalized word(s) or phrase(s) used to describe a tile matrix | MD_Keywords class in ISO 19115. See Table 1 | Zero or more (optional) One for each keyword authority used |
| scaleDenominator | Scale denominator of a tile matrix ^a | Double type | One (mandatory) |
| cellSize | Cell size of a tile matrix ^a | Double type | One (mandatory) |
| cornerOfOrigin | Corner of the tile matrix used as the origin for numbering tile rows and columns. | enumeration. See Table 8 | Zero or one (optional). Default value is "topLeft" |
| pointOfOrigin ^e | Position in CRS coordinates of the corner of origin for a tile matrix. | GM_Point data structure ^f | One (mandatory) |
| tileWidth | Width of each tile of a tile matrix in cells | Positive integer type | One (mandatory) |
| tileHeight | Height of each tile of a tile matrix in cells | Positive integer type | One (mandatory) |
| matrixWidth | Width of the matrix (number of tiles in width) | Positive integer type | One (mandatory) |
| matrixHeight | Height of the matrix (number of tiles in height) | Positive integer type | One (mandatory) |

^a The cell size of the tile can be obtained from the scaleDenominator by multiplying the latter by 0.28×10^{-3} / metersPerUnit. If the CRS uses meters as units of measure for the horizontal dimensions, then metersPerUnit = 1; if it uses degrees, then metersPerUnit = $2\pi a / 360$ (a is the Earth maximum radius of the ellipsoid; a.k.a the radius of the equator.).

^b The multilingual scoping rules in Clause 5.3.1 apply.

^c If no Title is specified, clients may display the Identifier value instead.

^d These TileMatrix identifiers SHALL be unique (different) within the context of the parent TileMatrixSet. Many applications use a correlative numeric value as an identifier. Other alternatives are a rounded scale denominator or a rounded cell size. Repeating the TileMatrixSet identifier as part of the TileMatrix identifier should be avoided.

^e In previous versions this attribute was called topLeftCorner and the concept of cornerOfOrigin did not exist

^f As specified in the ISO 19107. The CRS and order of these coordinates shall be as specified by the `crs` of the parent `TileMatrixSet`. These are the precise coordinates of the corner of origin (e.g. the top-left corner) for the tile matrix, which is also the corner of the (0, 0) tile. See Figure 5.

NOTE 1: It may be desirable to define a tile matrix set with some general-scale tile matrices in one CRS (e.g., CRS:84) and with detailed-scale tile matrices in a different CRS (e.g., LCC projection). However, this standard does not allow mixing CRSs. Each tile matrix set declares a single CRS.

NOTE 2: The width (`matrixWidth`) and height (`matrixHeight`) in tiles of each tile matrix is explicitly given, so the range of relevant tile indexes does not have to be calculated by the client application.

NOTE 3: The bounding box of a tile matrix is not supplied explicitly because it can be calculated from `cornerOfOrigin`, `pointOfOrigin`, `tileWidth`, `tileHeight` and `scaleDenominator`.

Table 8 – Parts of CornerOfOriginCode enumeration

| NAMES | DEFINITION |
|------------|---------------------------------|
| topLeft | Top left corner ^a |
| bottomLeft | Bottom left corner ^b |

^a The only possibility available in WMTS 1.0. Sometimes known as “xyz” in other non OGC specifications.

^b Used by Tile Map Service. Sometimes known as “tms” in other non OGC specifications

6.2.1.1. TileMatrixSet CRS Compatibility

In general, the CRS of the TileSets using a TileMatrixSet should be the same as the CRS of that TileMatrixSet. However, there are some situations where there is some flexibility:

- The CRS of the TileSet is a realization of the datum ensemble CRS specified in the TileMatrixSet. E.g. TileSet CRS: EPSG:9057 (G1762 realization of WGS84) and TileMatrixSet CRS: EPSG:4326 (WGS84)
- The CRS of the TileSet includes additional dimensions beyond the 2 specified in the CRS of the TileMatrixSet. E.g. TileSet CRS: EPSG:4979 (lat, lon, h in WGS84) and TileMatrixSet CRS: EPSG:4326 (lat, lon in WGS84)
- The CRS of the TileSet and the CRS of the TileMatrixSet only differ in axes ordering. E.g. TileSet CRS: EPSG:4326 (lat, lon) and TileMatrixSet CRS: CRS84 (lon, lat). The order specified in the TileMatrixSet only affects the coordinates order for the `PointOfOrigin` and optional `BoundingBox` within the TileMatrixSet definition itself. The CRS of the TileSet

affects the coordinates order for the data in the tiles, if applicable (e.g some formats of vector tiles)

6.2.2. VariableMatrixWidth requirements class

This requirements class provides the necessary support for variable matrix width tile matrix sets.

REQUIREMENTS CLASS 2

Target type tile matrix sets

Dependency <http://www.opengis.net/spec/tms/2.0/req/tilematrixset>

Label <http://www.opengis.net/spec/tms/2.0/req/variablematrixwidth>

REQUIREMENT 2

Label /req/variablematrixwidth/model

When a tiled resource or dataset has variable width tiles, the resource or dataset *shall* define the variable matrix width in a tile matrix set using a VariableMatrixWidth data structure. This will result in the following UML model shown in Figure 10 and model description in Table 9.



Figure 10 — VariableMatrixWidth UML model

In order to make the description of the model more compact, only the tile rows that have coalesced (i.e., coalescence factor larger than 1) will be encoded.

Table 9 — Parts of VariableMatrixWidth data structure

| NAMES | DEFINITION | DATA TYPE AND VALUES | MULTIPLICITY AND USE |
|------------|--|--|----------------------|
| coalesce | Coalescence factor | Positive integer type ^a | One (mandatory) |
| minTileRow | First tile row where the coalescence factor applies for a tilematrix | Non negative integer type ^b | One (mandatory) |

| NAMES | DEFINITION | DATA TYPE AND VALUES | MULTIPLICITY AND USE |
|--|--|--|----------------------|
| maxTileRow | Last tile row where the coalescence factor applies for a tilematrix | Non negative integer type ^c | One (mandatory) |
| ^a Shall be more than 1. Rows with Coalescence factor of 1 shall not be described here. | | | |
| ^b From 0 to maxTileRow. | | | |
| ^c From minTileRow to matrixWidth-1 of the tileMatrix section of the associated tileMatrixSet. | | | |

REQUIREMENT 3

Label /req/variablematrixwidth/coalescence1

Only the tile rows with a coalescence factor different from one shall be encoded. If a tile row is not mentioned in the VariableMatrixWidth description a coalescence factor of 1 shall be considered for that row.

7

TILEMATRIXSET ENCODINGS

TILEMATRIXSET ENCODINGS

7.1. JSON encoding

The JSON encoding is defined respecting the naming and types of the original classes. However, there are some differences. Table 10 describes some exceptions in the mapping between the class attributes and corresponding JSON element.

Table 10 — propertiesSchema attributes and JSON Schema properties equivalences

| CLASS ATTRIBUTE | JSON ELEMENT | REASON |
|-------------------|---|---|
| identifier | id | Following common practice in GeoJSON and JSON-LD. |
| BoundingBox class | array of 4 numbers representing lowerLeft and top Right coordinates | Follows GeoJSON (https://datatracker.ietf.org/doc/html/rfc7946) suggested encoding. |
| LanguageString | string | JSON files are generally used in the OGC API as monolingual documents. The language of the document is determined by the HTTP language negotiation headers. |
| keywords | string array | JSON files are generally used in the OGC API as monolingual documents. JSON does not use namespaces or codespaces. |
| WKT | object | The WKT encoding for JSON is an object representing a JSON encoding of the WKT for CRS 2.0 defined by https://proj.org/specifications/projjson.html |

NOTE: This Standard adopts the <https://proj.org/specifications/projjson.html> encoding, pending a resolution in the CRS group for adopting a possible future JSON encoding for WKT for CRS 2.0

In addition, all elements with multiplicity greater than one have names changed to plural. Please be aware of irregular plurals such as tileMatrix that changes to tileMatrices.

7.1.1. JSON TileMatrixSet requirements class

REQUIREMENTS CLASS 3

Target type tile matrix sets

REQUIREMENTS CLASS 3

| | |
|------------|---|
| Dependency | https://datatracker.ietf.org/doc/html/rfc7159 |
| Dependency | http://www.opengis.net/spec/tms/2.0/req/tilematrixset |
| Label | http://www.opengis.net/spec/tms/2.0/req/json-tilematrixset |

REQUIREMENT 4

| | |
|---|-------------------------------|
| Label | /req/json-tilematrixset/model |
| A TileMatrixSet instance encoded in JSON <i>shall</i> implement the class TileMatrixSet | |

REQUIREMENT 5

| | |
|--|------------------------------|
| Label | /req/json-tilematrixset/ietf |
| A TileMatrixSet instance encoded in JSON <i>shall</i> conform to IETF RFC 7159 | |

REQUIREMENT 6

| | |
|---|--------------------------------|
| Label | /req/json-tilematrixset/schema |
| A TileMatrixSet instance encoded in JSON <i>shall</i> validate using the JSON schema for a tile matrix set (http://schemas.opengis.net/tms/2.0/json/tileMatrixSet.json). | |

REQUIREMENT 7

| | |
|--|------------------------------------|
| Label | /req/json-tilematrixset/media-type |
| A TileMatrixSet instance encoded in an independent JSON document <i>shall</i> use the media type application/json. | |

NOTE: A TileMatrixSet description can be embedded in other file formats, such as a Service Metadata document of a WMTS service. In this case, the media type of the containing document prevails.

An annex provides Example encodings for Common TileMatrixSets (Informative) in JSON.

7.1.2. JSON VariableMatrixWidth requirements class

REQUIREMENTS CLASS 4

Target type tile matrix sets

Dependency <http://www.opengis.net/spec/tms/2.0/req/variablematrixwidth>

Dependency <http://www.opengis.net/spec/tms/2.0/req/json-tilematrixset>

Label <http://www.opengis.net/spec/tms/2.0/req/json-variablematrixwidth>

REQUIREMENT 8

Label /req/json-variablematrixwidth/model

A VariableMatrixWidth instance encoded in JSON *shall* implement the class VariableMatrixWidth.

REQUIREMENT 9

Label /req/json-variablematrixwidth/ietf

A VariableMatrixWidth instance encoded in JSON *shall* conform to IETF RFC 7159

REQUIREMENT 10

Label /req/json-variablematrixwidth/schema

A VariableMatrixWidth instance encoded in JSON *shall* validate using the JSON schema for a variable matrix width (<http://schemas.opengis.net/tms/2.0/json/tilematrixset.json#/definitions/variableMatrixWidth>)

An annex provides Example encodings for Variable Matrix Width TileMatrixSets (Informative) in JSON.

7.2. XML encoding

The XML encoding is defined respecting the naming and types of the original classes. However, all attribute names have been transformed to UpperCamelCase.

7.2.1. XML TileMatrixSet requirements class

REQUIREMENTS CLASS 5

| | |
|-------------|---|
| Target type | tile matrix sets |
| Dependency | https://www.w3.org/TR/xml/ |
| Dependency | http://www.opengis.net/spec/tms/2.0/req/tilematrixset |
| Label | http://www.opengis.net/spec/tms/2.0/req/xml-tilematrixset |

REQUIREMENT 11

| | |
|------------|------------------------------|
| Dependency | /req/tilematrixset |
| Label | /req/xml-tilematrixset/model |

A TileMatrixSet instance encoded in XML shall implement the class TileMatrixSet

REQUIREMENT 12

| | |
|--|-------------------------------|
| Label | /req/xml-tilematrixset/schema |
| A TileMatrixSet instance encoded in XML shall validate using the XML schema for a tile matrix set. | |

REQUIREMENT 13

| | |
|---|-----------------------------------|
| Label | /req/xml-tilematrixset/media-type |
| A TileMatrixSet instance encoded in an independent XML document shall use the media type application/xml. | |

NOTE: A TileMatrixSet description can be embedded in other file formats, such as a Service Metadata document of a WMTS service. In this case, the media type of the containing document prevails.

An annex provides Example encodings for Common TileMatrixSets (Informative) in XML.

7.2.2. XML VariableMatrixWidth requirements class

REQUIREMENTS CLASS 6

| | |
|-------------|---|
| Target type | tile matrix sets |
| Dependency | http://www.opengis.net/spec/tms/2.0/req/variablematrixwidth |
| Dependency | http://www.opengis.net/spec/tms/2.0/req/xml-tilematrixset |
| Label | http://www.opengis.net/spec/tms/2.0/req/xml-variablematrixwidth |

REQUIREMENT 14

| | |
|--|------------------------------------|
| Dependency | /req/variablematrixwidth |
| Dependency | /req/xml-tilematrixset |
| Label | /req/xml-variablematrixwidth/model |
| A VariableMatrixWidth instance encoded in XML <i>shall</i> implement the class VariableMatrixWidth | |

REQUIREMENT 15

| | |
|---|-------------------------------------|
| Label | /req/xml-variablematrixwidth/schema |
| A VariableMatrixWidth instance encoded in XML <i>shall</i> validate using the XML schema for a variable matrix width. | |

An annex provides Example encodings for Variable Matrix Width TileMatrixSets (Informative) in XML.

8

TILESETMETADATA

8.1. Overview

8.1.1. TileSet metadata

Tiles are identified by tileMatrix id, tileRow number and tileCol number. These three elements only have meaning if they are associated with a TileMatrixSet description that contains the necessary information (in terms of scaleDenominator, cellSize, pointOfOrigin and cornerOfOrigin) to transform the indices into coordinates in a known CRS. The main purpose of the TileSetMetadata is to link the TileSet with the TileMatrixSet description. In addition, the model contains elements describing the main characteristics of a TileSet, preserving the connection from the TileSet to the original data collection and styles as well as a recommended center point to start the navigation.

8.1.2. TileMatrixSet limits

Imagine a case where a tileset covers the whole bounding box of a tile matrix set. Now, imagine that the tileset extent needs to be expanded beyond the point and corner of origin of each TileMatrix. Changing the point of origin changes the position of any tile row and tile column indices. In other words, in the new tileset, tiles that cover the same bounding box as the previous tileset receive different tile row and tile column indices. This invalidates any cached tiles that the client could have stored and all client copies need to be updated. To overcome this problem, a dataset can optionally use a more generic TileMatrixSet that covers a bigger area (or even the entire globe, such as one of those defined in Annex D). In fact, that TileMatrixSet defining an area that might be covered by the dataset in the future could easily be re-used for many other datasets and become a common TileMatrixSet.

To inform the client about the valid range of tile indices in a tileset, the TileMatrixSetLimits concept is introduced. A list of TileMatrixSetLimits informs the minimum and maximum limits of these indices for each TileMatrix that contains actual data. The area outside these limits is considered empty space and is not covered by the tileset.



Figure 11 – TileMatrixSet Limits

8.2. Requirements classes

8.2.1. TileMatrixSetLimits requirements class

Requirements class `TileMatrixSetLimits` establishes how to describe the limits for a `TileSet` in the `TileMatrixSet`. It is expected that most `TileMatrixSets` will be defined only once and reused many times. In these circumstances, the data used to create the `TileSet` may only exist for a partial region or for a subset of scales. The array of `TileMatrixSetLimits` data structures allows for the declaration of a limited coverage of a `TileMatrixSet`. The identifying URI for this class is <http://www.opengis.net/spec/tms/2.0/req/tilematrixsetlimits>.

REQUIREMENTS CLASS 7

Target type tile set metadata

Dependency <http://www.opengis.net/spec/tms/2.0/req/tilematrixset>

Label <http://www.opengis.net/spec/tms/2.0/req/tilematrixsetlimits>

REQUIREMENT 16

Label /req/tilematrixsetlimits/model

- A A TileMatrixSetLimits instance SHALL consist of an array of Table 12 data structures with a multiplicity equal or inferior to the multiplicity of the tileMatrix of this tileMatrixSet and an optional boundingBox, as defined in the UML model shown in Figure 12
- B Each tileMatrix identifier SHALL be mentioned only once in this TileMatrixSetLimits. If a tileMatrix identifier is not mentioned, it should be interpreted as a tileMatrix that is not available.



Figure 12 – TileMatrixLimit array UML model

Table 11 – TileMatrixSetLimits array

| NAMES | DEFINITION | DATA TYPE AND VALUES | MULTIPLICITY AND USE |
|------------------------|-------------------------------------|---|----------------------------|
| tileMatrix SetLimit | Indices limits for a tile Matrix | TileMatrixSetLimits data structure, see Table 12 | one or more (mandatory) |

Table 12 – Parts of TileMatrixLimit data structure

| NAMES | DEFINITION | DATA TYPE AND VALUES | MULTIPLICITY AND USE |
|------------|--|--|----------------------|
| tileMatrix | Reference to a tileMatrix identifier | ows:CodeType, as adaptation of MD_Identifier class ISO 19115 ^a | One (mandatory) |
| minTileRow | Minimum tile row index valid for a tileset. | Non negative integer type ^b | One (mandatory) |

| NAMES | DEFINITION | DATA TYPE AND VALUES | MULTIPLICITY AND USE |
|------------|--|--|----------------------|
| maxTileRow | Maximim tile row index valid for a tileset. | Non negative integer type ^c | One (mandatory) |
| minTileCol | Minimum tile column index valid for a tileset. | Non negative integer type ^d | One (mandatory) |
| maxTileCol | Maximum tile column index valid for a tileset. | Non negative integer type ^e | One (mandatory) |

^a SHALL be an identifier to a tileMatrix element of this tileMatrixSet.

^b From 0 to maxTileRow.

^c From minTileRow to matrixWidth-1 of the tileMatrix of this tileMatrixSet.

^d From 0 to maxTileCol.

^e From minTileCol to tileHeight-1 of the tileMatrix of this tileMatrixSet.

8.2.2. TileSetMetadata requirements class

Requirements class TileSetMetadata establishes how to describe TileSet Metadata for a two-dimensional tile space. The TileSetMetadata data structure enables a resource to declare the use of a tile matrix set defined elsewhere and, if needed, a limited extent for this tile matrix set, the list of geospatial resources used to create the tileset and a recommended center point. Each TileSet in a geospatial resource should declare the use of a tile matrix set using this data structure. The identifying URI for this class is <http://www.opengis.net/spec/tms/2.0/req/tilesetmetadata>

REQUIREMENTS CLASS 8

| | |
|-------------|---|
| Target type | tile set metadata |
| Dependency | RFC 8288 (Web Linking) (optional) |
| Dependency | http://www.opengis.net/spec/tms/2.0/req/tilematrixset |
| Dependency | http://www.opengis.net/spec/tms/2.0/req/tilematrixsetlimits |
| Dependency | http://www.opengis.net/spec/tms/2.0/req/variablematrixwidth |
| Label | http://www.opengis.net/spec/tms/2.0/req/tilesetmetadata |

REQUIREMENT 17

Label /req/tilesetmetadata/identifier

- A A tiled resource or dataset SHALL declare support for a tile matrix set by one of the following two methods:
a link to a tile matrix set definition (e.g. one of the TileMatrixSet definitions from Annex D or Annex E)
as one of the links in the links list, or by explicitly including a TileMatrixSet definition (as an object in the tileMatrixSet property).
- B In an OGC API or an OGC Web Service and if the TileMatrixSet used is registered with the OGC Naming Authority, tileMatrixSetURI SHALL be populated with the canonical URI to the definition as listed on the OGC Definitions Server.

NOTE 1: The tileMatrixSet property with an object describing the TileMatrixSet is not intended for OGC APIs or OGC web services and it is included here for offline formats and encodings where links to resources are not possible or sensible.

NOTE 2: To determine if two resources or datasets use the same TileMatrixSet, compare their TileMatrixSet identifier. Alternatively, compare TileMatrixSet definitions for an equivalency (a simple calculation can be performed to verify whether or not two given tile matrices are aligned).

NOTE 3: If the same TileMatrixSet is externally available in more than one format, it is recommended that the format selected is the closer to the original description document format. For example, if an OGC API defines tiles using JSON, it is expected to link to a JSON definition of a TileMatrixSet.

REQUIREMENT 18

Dependency /req/tilematrixset

Dependency /req/tilematrixsetlimits

Label /req/tilesetmetadata/model

- A When a tiled resource or dataset has tiles available, the metadata describing the tiles (and optionally additional information such as the recommended center point and the data from which it was sourced) SHALL be described using the data model in the UML class diagram shown in Figure 13 and model description in Table 13.
- B When a tiled resource or dataset has tiles available only for a region or regions of the complete tiled space, the resource or dataset SHALL declare partial support to a tile matrix set using one or more tile matrix limits data structures defined in Table 12.



Figure 13 – TileSetMetadata UML model

Table 13 – Parts of TileSetMetadata data structure

| NAMES | DEFINITION | DATA TYPE AND VALUES | MULTIPLICITY AND USE |
|--------------------------|--|--|---|
| title ^a | Title of a TileSet, normally used for display to a human | LanguageString data structure. See Table 1 | Zero or more (optional) Include when available and useful Include one for each language represented |
| description ^a | Brief narrative description of a TileSet, normally | LanguageString data structure. See Table 1 | Zero or more (optional) Include when available and |

| NAMES | DEFINITION | DATA TYPE AND VALUES | MULTIPLICITY AND USE |
|-----------------------|---|---|---|
| | available for display to a human | | useful Include one for each language represented |
| keywords ^a | Unordered list of one or more commonly used or formalized word(s) or phrase(s) used to describe a TileSet | MD_Keywords class in ISO 19115 See Table 1 | Zero or more (optional) One for each keyword authority used |
| version | Version of a TileSet. Changes if the data behind the tiles has been changed | CharacterString | Zero or one (optional) |
| pointOfContact | Useful information to contact the authors or custodians for the TileSet | CharacterString (e.g. e-mail address, a physical address, phone numbers, etc) | Zero or one (optional) |
| attribution | Short reference to recognize the author or provider | CharacterString ^b | Zero or one (optional) |
| license | License applicable to the tiles | CharacterString | Zero or one (optional) |
| accessConstraints | Restrictions on the availability of the TileSet that the user needs to be aware of before using or redistributing the TileSet | ClassificationCode code list, see Table 17 | Zero or one (optional) |
| mediaType | Media types available for the tiles | CharacterString restricted by IETF RFC 6838, Section 4.2 | Zero or more (optional) ^c |
| dataType | Type of data represented in the tiles | DataTypeCode code list | one (mandatory) |
| crs | Coordinate Reference System (CRS) ^d | CRSType type, see Table 4 | one (mandatory) |
| epoch | Epoch of the Coordinate Reference System (CRS) | Number | Zero or one (optional) |
| tileMatrixSet | Tile matrix set definition | TileMatrixSet data structure. See Table 6 | Zero or one (optional) ^e |
| tileMatrixSetURI | Reference to a Tile Matrix Set on an official source for the Tile Matrix Set definitions | URI type ^f | Zero or One (optional) Include if the tile matrix set for this tileset is available in an accessible official source |
| tileMatrixSetLimit | Limits for the TileRow and TileCol values for each Tile Matrix in the tileMatrixSet | TileMatrixSetLimits data structure, see Table 11 | Zero or more (optional) Should be include when the boundary of the data is a |

| NAMES | DEFINITION | DATA TYPE AND VALUES | MULTIPLICITY AND USE |
|-------------|---|--|---|
| | | | fragment of the boundary of the tileMatrixSet ^g |
| boundingBox | Minimum bounding rectangle surrounding the TileSet | BoundingBox data structure, see Table 3 ^h | Zero or one (optional) |
| created | Timestamp indicating when the TileSet was first produced | DateTime | Zero or one (optional) |
| updated | Timestamp of the last Tile Set change/revision | DateTime | Zero or one (optional) |
| layer | Layer elements represented in the TileSet | GeospatialData data structure, see Table 14 | Zero or more (optional) |
| style | Style used to generate the tiles in the TileSet | Style data structure, see Table 16 | Zero or one (optional) ⁱ |
| centerPoint | Location of a tile that nicely represents the TileSet. Implementations may use this center value to set the default location or to present a representative tile in a user interface | TilePoint data structure, see Table 20. | Zero or more (optional) |
| link | Links to related resources | WebLink data structure, see Table 5. ^{e,j} | Zero or more (optional) |

^a The multilingual scoping rules in Clause 5.3.1 apply.

^b The intention is to show it in a corner of the viewport. It can contain markup and include a small logo image and links. In this case, note that when used to populate an HTML element there is a risk if it contains malicious scripts or reveals your identity to 3rd party domains.

^c Intended for offline use. In an online use you are supposed to provide links to the tiles that already have the mediaType specified.

^d It should be compatible with the CRS of the TileMatrixSet. In case the axis order is different from the TileMatrix Set the order of the CRS defined here prevails. See Clause 6.2.1.1

^e At least one of the TileMatrixSet, or a link with rel=tiling-scheme SHALL be provided.

^f Points to a definition of the TileMatrixSet in an official source for tile matrix sets such as the OGC Naming Authority's register of tile matrix sets (<http://www.opengis.net/def/tms>) (including definitions from Annex D and Annex E)

- ^g If missing, there are no limits other than the ones imposed by the TileMatrixSet. If present the TileMatrices listed are limited and the rest not available at all.
- ^h If the bounding box does not specify a CRS, it is inherited from the CRS of the TileSet.
- ⁱ If style property mentions a style applied to all layers, the style property in layer should not be used.
- ^j Possible link 'rel' values are: 'dataset' for a URL pointing to the dataset, 'item' for a URL template to get a tile; 'alternate' for a URL pointing to another representation of the TileSetMetadata (e.g a TileJSON file); 'tiling-scheme' for a definition of the TileMatrixSet; 'geodata' for pointing to a single collection (if the tileset represents a single collection);

A Layer is a set of geographic objects (all of the same type) together in a way that can be presented to the user. A layer can also be a coverage. Its elements are defined with a data structure defined in Table 14.

Table 14 – Parts of GeospatialData data structure

| NAMES | DEFINITION | DATA TYPE AND VALUES | MULTIPLICITY AND USE |
|--------------------------|--|--|---|
| title ^a | Title of the geospatial dataset, normally used for display to a human | LanguageString data structure. See Table 1 | Zero or more (optional) Include when available and useful Include one for each language represented |
| description ^a | Brief narrative description of a geospatial data, normally available for display to a human | LanguageString data structure. See Table 1 | Zero or more (optional) Include when available and useful Include one for each language represented |
| keywords ^a | Unordered list of one or more commonly used or formalized word(s) or phrase(s) used to describe the geospatial dataset | MD_Keywords class in ISO 19115 See Table 1 | Zero or more (optional) One for each keyword authority used |
| identifier | Unique identifier of the geospatial dataset | CodeType, as adaptation of MD_Identifier class ISO 19115 | One (mandatory) |
| dataType | Type of data represented in the geospatial dataset | DataTypeCode code list | one (mandatory) |
| geometryDimension | The geometry type of the features shown in the geospatial dataset | integer (0: points, 1: curves, 2: surfaces, 3: solids) | Zero or one (optional) |
| featureType | Feature type identifier | CharacterString | Zero or one (optional) ^b |

| NAMES | DEFINITION | DATA TYPE AND VALUES | MULTIPLICITY AND USE |
|---------------------|--|---|-------------------------------------|
| pointOfContact | Useful information to contact the authors or custodians for a geospatial data | CharacterString (e.g. e-mail address, a physical address, phone numbers, etc) | Zero or one (optional) |
| attribution | Short reference to recognize the author or provider | CharacterString ^c | Zero or one (optional) |
| license | License applicable to the tiles | CharacterString | Zero or one (optional) |
| publisher | Organization or individual responsible for making the geospatial dataset available | CharacterString | Zero or one (optional) |
| theme | Category where geospatial data can be grouped | CharacterString | Zero or more (optional) |
| crs | Coordinate Reference System (CRS) | CRSType type, see Table 4 | Zero or more (optional) |
| minScaleDenominator | Minimum scale denominator for usage of the geospatial data | double ^d | Zero or one (optional) ^e |
| minCellSize | Minimum cell size for usage of the geospatial data | double ^d | Zero or one (optional) ^e |
| maxScaleDenominator | Maximum cell size for usage of the geospatial data | double ^d | Zero or one (optional) ^f |
| maxCellSize | Maximum scale denominator for usage of the geospatial data | double ^d | Zero or one (optional) ^f |
| maxTileMatrix | TileMatrix identifier associated with the min ScaleDenominator | CharacterString ^g | Zero or one (optional) ^e |
| minTileMatrix | TileMatrix identifier associated with the max ScaleDenominator | CharacterString ^g | Zero or one (optional) ^f |
| boundingBox | Minimum bounding rectangle surrounding a geospatial data ^h | BoundingBox data structure, see Table 3 | Zero or one (optional) |
| created | Timestamp indicating when the geospatial data was first produced | DateTime | Zero or one (optional) |
| updated | Timestamp of the last geospatial data change/revision | DateTime | Zero or one (optional) |

| NAMES | DEFINITION | DATA TYPE AND VALUES | MULTIPLICITY AND USE |
|----------------|--|--|-------------------------------------|
| style | Style applied to the geospatial data to generate the tiles in the TileSet | Style data structure, see Table 16 | Zero or one (optional) ⁱ |
| geoDataClass | URI identifying a class of data contained in the geospatial data (useful to determine compatibility with styles or processes) | CodeType, as adaptation of MD_Identifier class ISO 19115 | Zero or more (optional) |
| propertySchema | Properties represented by the features in the geospatial data. Can be the attributes of a feature dataset (datatype='geometries) or the range Type of a coverage (datatype='coverage') | FeatureAttribute data structure. See Table 15 | Zero or more (optional) |
| link | Links to related resources | WebLink data structure, see Table 5. ^j | Zero or more (optional) |

- ^a The multilingual scoping rules in Clause 5.3.1 apply
- ^b Only applicable to geospatial data of datatype='geometries'
- ^c The intention is to show it in a corner of the viewport. It can contain markup and include a small logo image and links. In this case, note that when used to populate an HTML element there is a risk if it contains malicious scripts or reveals your identity to 3rd party domains.
- ^d SHALL be a scaleDenominator defined in one of the TileMatrix elements of the TileMatrixSet
- ^e If minCellSize, minScaleDenominator and maxTileMatrix are provided they SHALL be related to the same Tile Matrix
- ^f If maxCellSize, maxScaleDenominator and minTileMatrix are provided they SHALL be related to the same Tile Matrix
- ^g SHALL be an identifier to a tileMatrix element of this TileMatrixSet
- ^h In the same CRS as the TileSet
- ⁱ If the tileSetMetadata style property mentions a style applied to all geospatial data, this should be omitted
- ^j Possible link 'rel' values are: 'geodata' for a URL pointing to the collection of geospatial data.

NOTE 4: The link ‘rel’ used here with semantics of pointing from the GeospatialData class to point to a collection representing it cannot be ‘collection’ because IANA semantics for ‘collection’ implies that the source is an item and the target a ‘collection’ of items. We use ‘geodata’ instead.

A FeatureAttribute element contains attributes that can be found in at least one feature belonging to the layer the FeatureAttribute element belongs to. Its elements are defined in Table 15.

Table 15 – Parts of FeatureAttribute data structure

| NAMES | DEFINITION | DATA TYPE AND VALUES | MULTIPLICITY AND USE |
|--------------------------|---|--|--|
| title ^a | Title of a feature attribute, normally used for display to a human | LanguageString data structure. See Table 1 | Zero or more (optional) Include when available and useful Include one for each language represented ^b |
| description ^a | Brief narrative description of a feature attribute, normally available for display to a human | LanguageString data structure. See Table 1 | Zero or more (optional) Include when available and useful Include one for each language represented |
| keywords ^a | Unordered list of one or more commonly used or formalized word(s) or phrase(s) used to describe a feature attribute | MD_Keywords class in ISO 19115. See Table 1 | Zero or more (optional) One for each keyword authority used |
| identifier | Identifier of a feature attribute | CodeType, as adaptation of MD_Identifier class ISO 19115 | One (mandatory) |
| type | The data type of a feature attribute | CharacterString | One (mandatory) |
| pattern | Regular expression to validate the values of a feature attribute | CharacterString | Zero or one (optional) ^c |
| mediaType | Encodings of a complex feature attribute (e.g. image/png) | CharacterString restricted by IETF RFC 6838, Section 4.2 | Zero or one (optional) ^c |
| acceptedValues | Valid values of a feature attribute | CharacterString | Zero or more (optional) ^c |
| range | Range of valid values expressed as an array of two items | CharacterString | Zero or two (optional) ^c |
| lowerMultiplicity | Lower multiplicity of a feature attribute | Non negative integer | Zero or one (optional) ^d |

| NAMES | DEFINITION | DATA TYPE AND VALUES | MULTIPLICITY AND USE |
|---------------------|---|---|-------------------------------------|
| upperMultiplicity | Upper Multiplicity of a feature attribute | Non negative integer. Use '*' for 'unbounded' | Zero or one (optional) ^e |
| observedProperty | Measured phenomenon (variable) label, commonly a descriptive name | CharacterString | Zero or one (optional) |
| observedPropertyURI | URI pointing to a representation of the definition of the measured phenomenon (variable) | URI | Zero or one (optional) |
| uom | Units of measure characterizing the values of a feature attribute | CharacterString | Zero or one (optional) |
| uomURI | URI pointing to a representation of the definition of the units of measure characterizing the values of a feature attribute | CharacterString | Zero or one (optional) |

^a The multilingual scoping rules in Clause 5.3.1 apply.

^b f15

^c If missing all values compatible with the other restrictions are accepted

^d If missing, 0 (optional) is assumed

^e If missing, many (unbounded) is assumed

The style structure applicable to the geospatial resource is defined in Table 16.

Table 16 – Parts of Style data structure

| NAMES | DEFINITION | DATA TYPE AND VALUES | MULTIPLICITY AND USE |
|--------------------------|---|--|--|
| title ^a | Title of a style, normally used for display to a human | LanguageString data structure. See Table 1 | Zero or more (optional) Include when available and useful Include one for each language represented ^b |
| description ^a | Brief narrative description of a style, normally available for display to a human | LanguageString data structure. See Table 1 | Zero or more (optional) Include when available and useful Include one for each language represented |

| NAMES | DEFINITION | DATA TYPE AND VALUES | MULTIPLICITY AND USE |
|-----------------------|---|--|---|
| keywords ^a | Unordered list of one or more commonly used or formalized word(s) or phrase(s) used to describe a style | MD_Keywords class in ISO 19115. See Table 5 | Zero or more (optional) One for each keyword authority used |
| identifier | Identifier of a style | CodeType, as adaptation of MD_Identifier class ISO 19115 | One (mandatory) |
| link | Links to style related resources | WebLink data structure, see Table 5. ^c | Zero or more (optional) |

^a The multilingual scoping rules in Clause 5.3.1 apply

^b f16

^c Possible link 'rel' values are: 'style' for a URL pointing to the style description, 'styleSpec' for a URL pointing to the specification or standard used to define the style.

The levels of classification applicable to the TileSet is defined in Table 17.

Table 17 – Parts of ClassificationCode code list

| NAMES | DEFINITION |
|--------------|--|
| unclassified | Available for general disclosure |
| restricted | Not for general disclosure |
| confidential | Available for someone who can be entrusted with information |
| secret | Kept or meant to be kept private, unknown, or hidden from all but a select group of people |
| topSecret | Of the highest secrecy |

The data type applicable to the tileset or the layer is defined in Table 18.

Table 18 – Parts of DataTypeCode code list

| NAMES | DEFINITION |
|-------|---|
| map | Images representing colors for pictorial representation on the screen |

| NAMES | DEFINITION |
|----------|--|
| vector | Vector based elements. E.g. Features composed by geometries and properties |
| coverage | Coverage rangeset. E.g. Arrays of values representing physical quantities that are function of the position in a regular grid. |

The geometry dimensions applicable to the geometries of the layer are defined in the table below Table 19.

Table 19 – Geometry dimensions

| DIMENSIONS | DEFINITION |
|------------|---|
| 0 | 0D geometries (points, e.g. Point/MultiPoint) |
| 1 | 1D geometries (curves, e.g. LineString/MultiLineString) |
| 2 | 2D geometries (surfaces, e.g. Polygon/MultiPolygon) |
| 3 | 3D geometries (solids, e.g. polyhedrons) |

A center point is a place and scale that results in a tile that is representative of the tileset. A tile that contains some variety of objects, is visually appealing and easy to understand will be selected. The center point data structure applicable to the TileSet is defined in Table 20.

Table 20 – Parts of TilePoint data structure

| NAMES | DEFINITION | DATA TYPE AND VALUES | MULTIPLICITY AND USE |
|------------------|---|---|-------------------------------------|
| coordinates | Location of the center point in the TileSet | GM_Point data structure ^a | one (mandatory) |
| crs | Coordinate Reference System (CRS) | CRSType type, see Table 4 | Zero or one (optional) ^b |
| tileMatrix | Tile matrix identifier of the tile | CodeType, as adaptation of MD_Identifier class ISO 19115 ^c | One (mandatory) |
| scaleDenominator | Scale denominator of the tile | double ^d | Zero or one (optional) |
| cellSize | Cell size of the tile | double ^d | Zero or one (optional) |

^a As specified in ISO 19107. The CRS and order of these coordinates SHALL be as specified by the crs.

- b If unspecified, the default value is the CRS of the Tileset.
- c This identifier SHALL be one of the TileMatrices of the TileSet's TileMatrixSet.
- d If *cellSize* and *scaleDenominator* are provided, they SHALL correspond to those of the TileMatrix specified by the *tileMatrix* identifier.

9

TILESETMETADATA ENCODINGS

TILESETMETADATA ENCODINGS

9.1. JSON encoding

The JSON encoding has been done respecting the naming and types of the original classes. However, there are some differences exposed in the Clause 7 that also apply here. In particular Table 10 describes some exceptions in the mapping between the class attributes and corresponding JSON element.

9.1.1. JSON TileMatrixSetLimits requirements class

REQUIREMENTS CLASS 9

| | |
|-------------|---|
| Target type | tile set metadata |
| Dependency | https://datatracker.ietf.org/doc/html/rfc7159 |
| Dependency | http://www.opengis.net/spec/tms/2.0/req/tilematrixsetlimits |
| Label | http://www.opengis.net/spec/tms/2.0/req/json-tilematrixsetlimits |

REQUIREMENT 19

| | |
|------------|-------------------------------------|
| Dependency | /req/tilematrixsetlimits |
| Label | /req/json-tilematrixsetlimits/model |

A TileMatrixSetLimits instance encoded in JSON *shall* implement the class TileMatrixSetLimits

REQUIREMENT 20

| | |
|--|------------------------------------|
| Label | /req/json-tilematrixsetlimits/ietf |
| A TileMatrixSetLimits instance encoded in JSON <i>shall</i> conform to IETF RFC 7159 | |

REQUIREMENT 21

Label /req/json-tilematrixsetlimits/schema

A TileMatrixSetLimits instance encoded in JSON shall validate using the JSON schemas for a tile matrix set limits.

NOTE: A TileMatrixSetLimits description can be embedded within the TileSetMetadata, as for the OGC API – *Tiles* tileset conformance class.

An annex provides an Example JSON encoding of TileSetMetadata, including TileMatrixSetLimits.

9.1.2. JSON TileSetMetadata requirements class

REQUIREMENTS CLASS 10

Target type tile set metadata

Dependency <http://www.opengis.net/spec/tms/2.0/req/tilesetmetadata>

Dependency <http://www.opengis.net/spec/tms/2.0/req/json-tilematrixset>

Dependency <http://www.opengis.net/spec/tms/2.0/req/json-tilematrixsetlimits>

Dependency <http://www.opengis.net/spec/tms/2.0/req/json-tilematrixsetlimits>

Label <http://www.opengis.net/spec/tms/2.0/req/json-tilesetmetadata>

REQUIREMENT 22

Label /req/json-tilesetmetadata/model

A TileSetMetadata instance encoded in JSON *shall* implement the class TileSetMetadata

REQUIREMENT 23

Label /req/json-tilesetmetadata/ietf

A TileSetMetadata instance encoded in JSON *shall* conform to IETF RFC 7159

REQUIREMENT 24

Label /req/json-tilesetmetadata/schema

A TileSetMetadata instance encoded in JSON *shall* validate using the JSON schema for a TileSetMetadata (<http://schemas.opengis.net/tms/2.0/json/tileSet.json>).

REQUIREMENT 25

Label /req/json-tilesetmetadata/media-type

A TileSetMetadata instance encoded in an independent JSON document *shall* use the media type application/json.

NOTE: A TileSetMetadata description can be embedded in other file formats, such as a Service Metadata document of a WMTS service. In this case, the media type of the containing document prevails.

An annex provides an Example XML encoding of TileSetMetadata.

The encoding of PropertySchema adopts the JSON Schema form starting with an element propertiesSchema that defines the GeoJSON element “properties” for this layer (the composition of “properties” is undefined by GeoJSON but it can be defined for a layer instance if its features follow a data model). Table 21 describes the mapping between the FeatureAttribute class attributes (in Table 15) and the JSON schema properties.

Table 21 – propertiesSchema attributes and JSON Schema properties equivalences

| .PROPERTIES_SCHEMA ATTRIBUTES | JSON SCHEMA PROPERTIES |
|-------------------------------|--|
| title | title |
| keywords | N/A |
| identifier | name of the additional property |
| type | combination of ‘type’ and ‘format’ |
| pattern | pattern |
| mediaType | contentMediaType |
| acceptedValues | enum |
| range | a combination of ‘maximum’, ‘exclusiveMaximum’, ‘minimum’ and ‘exclusiveMinimum’ |

| .PROPERTIES SCHEMA ATTRIBUTES | JSON SCHEMA PROPERTIES |
|-------------------------------|------------------------|
| lowerMultiplicity | minItems |
| upperMultiplicity | maxItems |
| observedProperty | N/A |
| observedPropertyURI | N/A |
| uom | N/A |
| uomURI | N/A |

9.2. XML encoding

The XML encoding has been done respecting the naming and types of the original classes. However all attribute names have been transformed to UpperCamelCase.

9.2.1. XML TileMatrixSetLimits requirements class

| REQUIREMENTS CLASS 11 | |
|-----------------------|---|
| Target type | tile set metadata |
| Dependency | https://www.w3.org/TR/xml/ |
| Dependency | http://www.opengis.net/spec/tms/2.0/req/tilematrixsetlimits |
| Label | http://www.opengis.net/spec/tms/2.0/req/xml-tilematrixsetlimits |

| REQUIREMENT 26 | |
|----------------|------------------------------------|
| Dependency | /req/tilematrixsetlimits |
| Label | /req/xml-tilematrixsetlimits/model |

A TileMatrixSetLimits instance encoded in XML SHALL implement the class TileMatrixSetLimits

REQUIREMENT 27

Label /req/xml-tilematrixsetlimits/schema

A TileMatrixSetLimits instance encoded in XML shall validate using the XML schemas for a tile matrix set limits.

NOTE: A TileMatrixSetLimits is normally used as embedded in other XML documents. That is the reason an associated media type is not provided.

An annex provides an Example XML encoding of TileSetMetadata including TileMatrixSetLimits.

9.2.2. XML TileSetMetadata requirements class

REQUIREMENTS CLASS 12

Target type tile set metadata

Dependency <http://www.opengis.net/spec/tms/2.0/req/tilessetmetadata>

Dependency <http://www.opengis.net/spec/tms/2.0/req/xml-tilematrixset>

Dependency <http://www.opengis.net/spec/tms/2.0/req/xml-tilematrixsetlimits>

Dependency <http://www.opengis.net/spec/tms/2.0/req/xml-variablematrixwidth>

Label <http://www.opengis.net/spec/tms/2.0/req/xml-tilessetmetadata>

REQUIREMENT 28

Label /req/xml-tilessetmetadata/model

A TileSetMetadata instance encoded in XML shall implement the class TileSetMetadata

REQUIREMENT 29

Label /req/xml-tilessetmetadata/schema

A TileSetMetadata instance encoded in XML shall validate using the XML schema for a TileSetMetadata.

REQUIREMENT 30

Label /req/xml-tilessetmetadata/media-type

A TileSetMetadata instance encoded in an independent XML document shall use the media type application/xml.

NOTE: A TileSetMetadata does not currently have an associated media type.

An annex provides an Example XML encoding of TileSetMetadata.



A

ANNEX A (NORMATIVE) CONFORMANCE CLASS ABSTRACT TEST SUITE

ANNEX A (NORMATIVE)

CONFORMANCE CLASS ABSTRACT TEST SUITE

An implementation of this standard must satisfy the following system characteristics to be conformant with this specification.

A.1. Conformance Class TileMatrixSet

CONFORMANCE CLASS A.1

| | |
|-------------|---|
| Subject | Requirements Class "TileMatrixSet" |
| Target type | tile matrix sets |
| Label | http://www.opengis.net/spec/tms/2.0/conf/tilematrixset |

A.1.1. Model

ABSTRACT TEST A.1

| | |
|--------------|---|
| Subject | Clause 6.2.1, Requirement 1 |
| Label | /conf/tilematrixset/model |
| Test purpose | Validate that a tile matrix set follows the UML model and the model description in tables |
| Test method | Validate the requirements of the model Test passes if TileMatrixSet instances point to the TileMatrixSet data type definition and follow the data model specified in the Tables related to the requirement and its dependencies. |

A.2. Conformance Class VariableMatrixWidth

CONFORMANCE CLASS A.2

| | |
|-------------|---|
| Subject | Requirements Class “VariableMatrixWidth” |
| Target type | tile matrix sets |
| Label | http://www.opengis.net/spec/tms/2.0/conf/variablematrixwidth |

A.2.1. Model

ABSTRACT TEST A.2

| | |
|--------------|--|
| Subject | Abstract test A.2 |
| Label | /conf/variablematrixwidth/model |
| Test purpose | Validate that for a tiled resource with variable width tiles, the resource defines the variable matrix width in a tile matrix set using a VariableMatrixWidth data structure. |
| Test method | Validate the requirements of the model Test passes if VariableMatrixWidth instances point to the VariableMatrixWidth data type definition and follow the data model specified in the requirement tables and its dependencies. |

A.2.2. Coalescence

ABSTRACT TEST A.3

| | |
|--------------|---|
| Subject | Clause 6.2.2, Requirement 3 |
| Label | /conf/variablematrixwidth/coalescence1 |
| Test purpose | Validate that all coalescence factors specified in variable width tile rows are greater than 1. |
| Test method | Validate the requirements of the model Test passes if all VariableMatrixWidth elements in the instance have a coalescence factor greater than 1. |

A.3. Conformance Class JSON TileMatrixSet

CONFORMANCE CLASS A.3

| | |
|-------------|---|
| Subject | Requirements Class “JSON TileMatrixSet” |
| Target type | tile matrix sets |
| Label | http://www.opengis.net/spec/tms/2.0/conf/json-tilematrixset |

A.3.1. Model

ABSTRACT TEST A.4

| | |
|--------------|--|
| Subject | Clause 7.1.1, Requirement 4 |
| Label | /conf/json-tilematrixset/model |
| Test purpose | Validate that a TileMatrixSet instance encoded in JSON implements the class TileMatrixSet. |
| Test method | Validate the requirements of the model Test passes if TileMatrixSet instances follow the data model specified in the requirement, associated tables and its dependencies. |

A.3.2. IETF

ABSTRACT TEST A.5

| | |
|--------------|---|
| Subject | Clause 7.1.1, Requirement 5 |
| Label | /conf/json-tilematrixset/ietf |
| Test purpose | Validate that a TileMatrixSet instance encoded in JSON conforms to IETF RFC 7159 |
| Test method | Validate the requirements of the IETF Test passes if TileMatrixSet JSON instances pass format validation against the IETF rules. |

A.3.3. Schema

ABSTRACT TEST A.6

| | |
|--------------|---|
| Subject | Clause 7.1.1, Requirement 6 |
| Label | /conf/json-tilematrixset/schema |
| Test purpose | Verify that a TileMatrixSet instance encoded in JSON validates using the JSON schema for a tile matrix set. |
| Test method | Validate the requirements of the model Test passes if TileMatrixSet JSON instances pass validation against the tile matrix set JSON Schemas. |

A.3.4. Media type

ABSTRACT TEST A.7

| | |
|--------------|--|
| Subject | Clause 7.1.1, Requirement 7 |
| Label | /conf/json-tilematrixset/media-type |
| Test purpose | Validate that a TileMatrixSet instance encoded in an independent JSON document uses the media type application/json. |
| Test method | Validate the requirements of the media type Test passes if the independent instances of TileMatrixSet are exposed as application/json media type. |

A.4. Conformance Class JSON VariableMatrixWidth

CONFORMANCE CLASS A.4

| | |
|-------------|---|
| Subject | Requirements Class “JSON VariableMatrixWidth” |
| Target type | tile matrix sets |
| Label | http://www.opengis.net/spec/tms/2.0/conf/json-variablematrixwidth |

A.4.1. Model

ABSTRACT TEST A.8

| | |
|--------------|---|
| Subject | Clause 7.1.2, Requirement 8 |
| Label | /conf/json-variablematrixwidth/model |
| Test purpose | Validate that a VariableMatrixWidth instance encoded in JSON implements the class VariableMatrixWidth |
| Test method | Validate the requirements of the model Test passes if VariableMatrixWidth instances follow the data model specified in the requirement and associated tables and its dependencies. |

A.4.2. IETF

ABSTRACT TEST A.9

| | |
|--------------|---|
| Subject | Clause 7.1.2, Requirement 9 |
| Label | /conf/json-variablematrixwidth/ietf |
| Test purpose | Validate that a VariableMatrixWidth instance encoded in JSON conforms to IETF RFC 7159 |
| Test method | Validate the requirements of the IETF rules Test passes if VariableMatrixWidth JSON instances pass format validation against the IETF rules. |

A.4.3. Schema

ABSTRACT TEST A.10

| | |
|--------------|---|
| Subject | Clause 7.1.2, Requirement 10 |
| Label | /conf/json-variablematrixwidth/schema |
| Test purpose | Verify that a VariableMatrixWidth instance encoded in JSON validates using the JSON schema for a variable matrix width. |

ABSTRACT TEST A.10

| | |
|-------------|--|
| Test method | Validate the requirements of the schema Test passes if VariableMatrixWidth JSON instances pass validation against the variable matrix width JSON Schemas. |
|-------------|--|

A.5. Conformance Class XML TileMatrixSet

CONFORMANCE CLASS A.5

| | |
|-------------|---|
| Subject | Requirements Class “VariableMatrixWidth” |
| Target type | tile matrix sets |
| Label | http://www.opengis.net/spec/tms/2.0/conf/xml-tilematrixset |

A.5.1. Model

ABSTRACT TEST A.11

| | |
|--------------|--|
| Subject | Clause 7.2.1, Requirement 11 |
| Label | /conf/xml-tilematrixset/model |
| Test purpose | Validate that a TileMatrixSet instance encoded in XML implements the class TileMatrixSet. |
| Test method | Validate the requirements of the model Test passes if TileMatrixSet instances use a TileMatrixSet XML data type definition that follows the data model specified in the requirement and associated tables and its dependencies. |

A.5.2. Schema

ABSTRACT TEST A.12

| | |
|---------|------------------------------|
| Subject | Clause 7.2.1, Requirement 12 |
|---------|------------------------------|

ABSTRACT TEST A.12

| | |
|--------------|---|
| Label | /conf/xml-tilematrixset/schema |
| Test purpose | Verify that a TileMatrixSet instance encoded in XML validates using the XML schema for a tile matrix set. |
| Test method | Validate the requirements of the model Test passes if TileMatrixSet XML instances pass validation against the tile matrix set XML Schemas. |

A.5.3. Media Type

ABSTRACT TEST A.13

| | |
|--------------|--|
| Subject | Clause 7.2.1, Requirement 13 |
| Label | /conf/xml-tilematrixset/media-type |
| Test purpose | Validate that a TileMatrixSet instance encoded in an independent XML document uses the media type application/xml. |
| Test method | Validate the requirements of the media type Test passes if the independent instances of TileMatrixSet are exposed as application/xml MIME type. |

A.6. Conformance Class XML VariableMatrixWidth

CONFORMANCE CLASS A.6

| | |
|-------------|---|
| Subject | Requirements Class “XML VariableMatrixWidth” |
| Target type | tile matrix sets |
| Label | http://www.opengis.net/spec/tms/2.0/conf/xml-variablematrixwidth |

A.6.1. Model

ABSTRACT TEST A.14

Subject Clause 7.2.2, Requirement 14

Label /conf/xml-variablematrixwidth/model

Test purpose Validate that a TileSetMetadata encoded in XML implements the class TileSetMetadata.

Test method Validate the requirements of the model

Test method Test passes if VariableMatrixWidth instances use a VariableMatrixWidth XML data type definition that follows the data model specified in the requirement and associated tables its dependencies.

A.6.2. Schema

ABSTRACT TEST A.15

Subject Clause 7.2.2, Requirement 15

Label /conf/xml-variablematrixwidth/schema

Test purpose Verify that a TileSetMetadata encoded in XML validates using the XML schema for a tile matrix set link.

Test method Validate the requirements of the model

Test method Test passes if VariableMatrixWidth XML instances pass validation against the variable matrix width XML Schemas.

A.7. Conformance Class TileMatrixSetLimits

CONFORMANCE CLASS A.7

Subject Requirements Class “TileMatrixSetLimit”

Target type tile matrix sets

Label <http://www.opengis.net/spec/tms/2.0/conf/tilematrixsetlimits>

A.7.1. Model

ABSTRACT TEST A.16

Subject Clause 8.2.1, Requirement 16

Label /conf/tilematrixsetlimits/model

Test purpose Validate that a TileMatrixSetLimits instance follows the UML model and model description. Validate that each tileMatrix identifier is mentioned only once in the TileMatrixSetLimits.

Test method Validate the requirements of the model
Test passes if TileMatrixSetLimits instances point to the TileMatrixSetLimits data type definition and follow the data model specified in the requirements and associated tables and its dependencies.
Test passes if all tileMatrix identifier are different in this TileMatrixSetLimits

A.8. Conformance Class TileSetMetadata

CONFORMANCE CLASS A.8

Subject Requirements Class “TileSetMetadata”

Target type tile set metadata

Label <http://www.opengis.net/spec/tms/2.0/conf/tilesetmetadata>

A.8.1. Identifier

ABSTRACT TEST A.17

Subject Clause 8.2.2, Requirement 17

Label /conf/tilematrixsetmetadata/identifier

Test purpose Validate that a tiled resource or dataset declares support to a tile matrix set by one of the following two methods: a link to a tile matrix set definition (e.g. one of the Tile

ABSTRACT TEST A.17

MatrixSet definitions from Annex D or Annex E) as one of the links in the links list, or by explicitly including a TileMatrixSet definition (as an object in the tileMatrixSet property).

| | |
|-------------|--|
| Test method | Validate the requirements of the model Test passes if a tiled resource or dataset declares support to a tile matrix set by one of the following two methods: a link to a tile matrix set definition (including the TileMatrixSet definition from Annex D and Annex G) as one of the links in the links list or by explicitly including a TileMatrixSet definition (as an object in the tileMatrixSet property). |
|-------------|--|

A.8.2. Model

ABSTRACT TEST A.18

Subject Clause 8.2.2, Requirement 18

Label /conf/tilematrixsetmetadata/model

Test purpose Validate that when a tiled resource or dataset has tiles available, the metadata describing the tiles is described using the data model in UML model shown in Figure 13 and model description in Table 13.

Test method Test passes if TileSetMetadata instances point to the TileSetMetadata data type definition and follow the data model specified in the requirement and associated tables and its dependencies.

A.9. Conformance Class JSON TileMatrixSetLimits

CONFORMANCE CLASS A.9

Subject Requirements Class “JSON TileMatrixSetLimits”

Target type tile set metadata

Label <http://www.opengis.net/spec/tms/2.0/conf/json-tilematrixsetlimits>

A.9.1. Model

ABSTRACT TEST A.19

Subject Clause 9.1.1, Requirement 19

Label /conf/json-tilematrixsetlimits/model

Test purpose Validate that a TileMatrixSetLimits instance encoded in JSON implements the class TileMatrixSetLimits

Test method Validate the requirements of the model
Test passes if TileMatrixSetLimits instances follow the data model specified in the requirement and associated tables and its dependencies.

A.9.2. IETF

ABSTRACT TEST A.20

Subject Clause 9.1.1, Requirement 20

Label /conf/json-tilematrixsetlimits/ietf

Test purpose Validate that a TileMatrixSetLimits instance encoded in JSON conforms to IETF RFC 7159

Test method Validate the requirements of the IETF
Test passes if TileMatrixSetLimits JSON instances pass format validation against the IETF rules.

A.9.3. Schema

ABSTRACT TEST A.21

Subject Clause 9.1.1, Requirement 21

Label /conf/json-tilematrixsetlimits/schema

Test purpose Verify that a TileMatrixSetLimits instance encoded in JSON validates using the JSON schema for a tile matrix set.

ABSTRACT TEST A.21

| | |
|-------------|--|
| Test method | Validate the requirements of the model Test passes if TileMatrixSetLimits JSON instances pass validation against the tile matrix set limits JSON Schemas. |
|-------------|--|

A.10. Conformance Class JSON TileSetMetadata

CONFORMANCE CLASS A.10

| | |
|-------------|---|
| Subject | Requirements Class “JSON TileSetMetadata” |
| Target type | tile set metadata |
| Label | http://www.opengis.net/spec/tms/2.0/conf/json-tilesetmetadata |

A.10.1. Model

ABSTRACT TEST A.22

| | |
|--------------|---|
| Label | /conf/json-tilesetmetadata/model |
| Test purpose | Validate that a TileSetMetadata encoded in JSON implements the class Tile SetMetadata |
| Test method | Validate the requirements of the model Test passes if TileSetMetadata instances follow the data model specified in the requirement and associated tables and its dependencies. |

A.10.2. IETF

ABSTRACT TEST A.23

| | |
|--------------|---|
| Subject | Clause 9.1.2, Requirement 23 |
| Label | /conf/json-tilematrixsetlimits/ietf |
| Test purpose | Validate that a TileSetMetadata encoded in JSON conforms to IETF RFC 7159 |

ABSTRACT TEST A.23

| | |
|-------------|---|
| Test method | Validate the requirements of the IETF Test passes if TileSetMetadata JSON instances pass format validation against the IETF rules. |
|-------------|---|

A.10.3. Schema

ABSTRACT TEST A.24

| | |
|--------------|--|
| Subject | Clause 9.1.2, Requirement 25 |
| Label | /conf/json-tilematrixsetlimits/schema |
| Test purpose | Verify that a TileSetMetadata instance encoded in JSON validates using the JSON schema for a tile set metadata. |
| Test method | Validate the requirements of the schema Test passes if TileSetMetadata JSON instances pass validation against the tile set metadata JSON Schemas. |

A.10.4. Media type

ABSTRACT TEST A.25

| | |
|--------------|--|
| Subject | Clause 9.1.2, Requirement 25 |
| Label | /conf/json-tilesetmetadata/media-type |
| Test purpose | Validate that a TileSetMetadata encoded in an independent JSON document uses the media type application/json. |
| Test method | Validate the requirements of the media type Test passes if the independent instances of TileSetMetadata are exposed as application/json media type. |

A.11. Conformance Class XML TileMatrixSetLimits

CONFORMANCE CLASS A.11

Subject Requirements Class “XML TileMatrixSetLimits”

Target type tile set metadata

Label <http://www.opengis.net/spec/tms/2.0/conf/xml-tilematrixsetlimits>

A.11.1. Model

ABSTRACT TEST A.26

Subject Clause 9.2.1, Requirement 27

Label /conf/xml-tilematrixsetlimits/model

Test purpose Validate that a TileMatrixSetLimits instance encoded in XML implements the class TileMatrixSetLimits.

Test method Validate the requirements of the model
Test passes if TileMatrixSetLimits instances point to the TileMatrixSetLimits data type definition and follow the data model specified in the requirement and in the associated tables and its dependencies.

ABSTRACT TEST A.27

Subject Clause 9.2.1, Requirement 27

Label /conf/xml-tilematrixsetlimits/schema

Test purpose Verify that a TileMatrixSetLimits instance encoded in XML validates using the XML schemas for a tile matrix set limits.

Test method Validate the requirements of the schema
Test passes if TileMatrixSetLimits XML instances pass validation against the tile matrix set limits XML Schemas.

A.12. Conformance Class XML TileSetMetadata

CONFORMANCE CLASS A.12

| | |
|-------------|---|
| Subject | Requirements Class “XML TileSetMetadata” |
| Target type | tile set metadata |
| Label | http://www.opengis.net/spec/tms/2.0/conf/xml-tilesetmetadata |

A.12.1. Model

ABSTRACT TEST A.28

| | |
|--------------|--|
| Subject | Clause 9.2.2, Requirement 28 |
| Label | /conf/xml-tilematrixsetmetadata/model |
| Test purpose | Validate that a TileSetMetadata encoded in XML implements the class TileSetMetadata. |
| Test method | Validate the requirements of the model Test passes if TileSetMetadata instances use a TileSetMetadata XML data type definition that follows the data model specified in the requirement and associated tables and its dependencies. |

A.12.2. Schema

ABSTRACT TEST A.29

| | |
|--------------|---|
| Subject | Clause 9.2.2, Requirement 29 |
| Label | /conf/xml-tilematrixsetmetadata/schema |
| Test purpose | Verify that a TileSetMetadata encoded in XML validates using the XML schema for a tile set metadata. |
| Test method | Validate the requirements of the model Test passes if TileSetMetadata XML instances pass validation against the tile set metadata XML Schemas. |

A.12.3. Media Type

ABSTRACT TEST A.30

Subject Clause 9.2.2, Requirement 30

Label /conf/xml-tilematrixset/media-type

Test purpose Validate that a TileSetMetadata encoded in an independent XML document uses the media type application/xml.

Test method Validate the requirements of the media type
Test passes if the independent instances of TileSetMetadata are exposed as application/xml MIME type.

B

ANNEX B (NORMATIVE) SCHEMA DOCUMENTS

ANNEX B (NORMATIVE) SCHEMA DOCUMENTS

In addition to this document, this standard includes several normative Schema Documents. These Schema Documents are posted online at the URL <http://schemas.opengis.net/tms/2.0>.

The schemas for both JSON and XML encodings of TileMatrixSets are reproduced in the Annex F section of this document, along with examples. Additional examples are found in the Annex G section.

The schemas for both JSON and XML encodings of TileSet Metadata are reproduced in the Annex H sections of this document, along with examples.

B.1. JSON Schema

The JSON Schema Documents are situated in the json subfolder and are named:

- json/tileMatrixSet.json
- json/tileMatrixLimits.json
- json/tileSet.json

They include the schemas necessary to JSON-validate the classes JSONTileMatrixSet, JSONTileMatrixSetLimits and JSONTileSetMetadata, respectively.

In addition, the directory named json/examples/tilematrixset contains examples of the JSON TileMatrixSets encodings, while the directory named json/examples/tileset contains examples of the JSON tileset metadata encodings.

B.2. XML Schema

The XML Schema Documents are situated in the xml subfolder and are named:

- xml/tilematrixset.xsd

- `xml/tilematrixlimits.xsd`
- `xml/tileset.xsd`

They include the schemas necessary to XML-validate the classes `XMLTileMatrixSet`, `XMLTileMatrixSetLimits` and `XMLTileSetMetadata`, respectively.

In addition, the directory named `xml/examples/tilematrixset` contains examples of the XML `TileMatrixSets` encodings, while the directory named `xml/examples/tileset` contains examples of XML tileset metadata encodings.



C

ANNEX C (INFORMATIVE) WELL-KNOWN SCALE SETS

ANNEX C (INFORMATIVE) WELL-KNOWN SCALE SETS

The following well-known scale sets (WKSS) are defined in this standard. To be conformant to a WKSS, the tile matrices of a tile matrix set should only include a consecutive subset of the scales defined in one of the following tables (or their implied extensions). Note that the correspondence between the numeric identifiers of a TileMatrixSet and those of a WKSS might be offset by a fixed number of scales. Cell sizes (in terrain units) are calculated assuming 0.28 mm pixel size and the WGS84 equatorial Earth diameter.

The WKSS concept was introduced in WMTS to improve interoperability, but experience has demonstrated that the use of common TileMatrixSets such as those registered on the [OGC Naming Authority's register](#), and defined in the common tile matrix sets and variable width tile matrix sets definitions annexes, is even better. The use of WKSS is no longer encouraged by this standard.

C.1. GlobalCRS84Scale

URI: <http://www.opengis.net/def/wkss/OGC/1.0/GlobalCRS84Scale>

This WKSS has been defined for global cartographic products. Rounded scales have been chosen for intuitive cartographic representation of vector data. The scale denominator is only accurate near the Equator.

Table C.1 – Definition of Well-known scale set GlobalCRS84Scale

| CRS | SCALE DENOMINATOR | CELL SIZE (DEGREES) |
|---|-------------------|---------------------|
| http://www.opengis.net/def/crs/OGC/1.3/CRS84 | 500,000,000 | 1.25764139776733 |
| | 250,000,000 | 0.628820698883665 |
| | 100,000,000 | 0.251528279553466 |
| | 50,000,000 | 0.125764139776733 |

| CRS | SCALE DENOMINATOR | CELL SIZE (DEGREES) |
|-----|-------------------|-----------------------------------|
| | 25,000,000 | $6.28820698883665 \times 10^{-2}$ |
| | 10,000,000 | $2.51528279553466 \times 10^{-2}$ |
| | 5,000,000 | $1.25764139776733 \times 10^{-2}$ |
| | 2,500,000 | $6.28820698883665 \times 10^{-3}$ |
| | 1,000,000 | $2.51528279553466 \times 10^{-3}$ |
| | 500,000 | $1.25764139776733 \times 10^{-3}$ |
| | 250,000 | $6.28820698883665 \times 10^{-4}$ |
| | 100,000 | $2.51528279553466 \times 10^{-4}$ |
| | 50,000 | $1.25764139776733 \times 10^{-4}$ |
| | 25,000 | $6.28820698883665 \times 10^{-5}$ |
| | 10,000 | $2.51528279553466 \times 10^{-5}$ |
| | 5000 | $1.25764139776733 \times 10^{-5}$ |
| | 2500 | $6.28820698883665 \times 10^{-6}$ |
| | 1000 | $2.51528279553466 \times 10^{-6}$ |
| | 500 | $1.25764139776733 \times 10^{-6}$ |
| | 250 | $6.28820698883665 \times 10^{-7}$ |
| | 100 | $2.51528279553466 \times 10^{-7}$ |

C.2. GlobalCRS84Pixel

URI: <http://www.opengis.net/def/wkss/OGC/1.0/GlobalCRS84Pixel>

This WKSS has been defined for global cartographic products. Rounded cell sizes have been chosen for intuitive cartographic representation of raster data. Some values have been chosen to coincide with original cell size of commonly used global products like STRM (1" and 3"), GTOPO (30") or ETOPO (2' and 5'). The scale denominator and approximated cell size in meters are only accurate near the Equator.

Table C.2 – Definition of Well-known scale set GlobalCRS84Pixel

| CRS | SCALE DENOMINATOR | CELL SIZE (DEGREES) | APPROX CELL SIZE (M) |
|---|-------------------------|---|-------------------------------|
| | 795,139,219. 9519541 | 2 | 240,000 |
| | 397,569,609. 9759771 | 1 | 120,000 |
| | 198,784,804. 9879885 | 0.5 (30') | 60,000 |
| | 132,523,203. 3253257 | 0. 3333333333333333 (20') | 40,000 |
| | 66,261,601. 66266284 | 0. 1666666666666720,000 (10') | 720,000 |
| http://www.opengis.net/def/crs/OGC/1.3/CRS84 | 33,130,800. 83133142 | 8. 3333333333333333 $\times 10^{-2}$ (5') | 10,000 |
| | 13,252,320. 33253257 | 3. 33333333333333334000 $\times 10^{-2}$ (2') | 4000 |
| | 6,626,160. 166266284 | 1. 666666666666666672000 $\times 10^{-2}$ (1') | 666666666666666672000 |
| | 3,313,080. 083133142 | 8. 33333333333333331000 $\times 10^{-3}$ (30'') | 33333333333333331000 |

| CRS | SCALE DENOMINATOR | CELL SIZE (DEGREES) | APPROX CELL SIZE (M) |
|-----|-------------------------|--|-------------------------------|
| | 1,656,540. 041566571 | 4. 16666666666666667,500 $\times 10^{-3}$ (15") | |
| | 552,180. 0138555236 | 1. 388888888888889166 $\times 10^{-3}$ (5") | |
| | 331,308. 0083133142 | 8. 33333333333333333,100 $\times 10^{-4}$ (3") | |
| | 110,436. 0027711047 | 2. 777777777777777833 $\times 10^{-4}$ (1") | |
| | 55,218. 00138555237 | 1. 38888888888888888,16 $\times 10^{-4}$ (0.5") | |
| | 33,130. 80083133142 | 8. 333333333333333310 $\times 10^{-5}$ (0.3") | |
| | 11,043. 60027711047 | 2. 77777777777777773,3 $\times 10^{-5}$ (0.1") | |
| | 3313. 080083133142 | 8. 33333333333333331 $\times 10^{-6}$ (0.03") | |
| | 1104. 360027711047 | 2. 77777777777777770,33 $\times 10^{-6}$ (0.01") | |

C.3. GoogleCRS84Quad

URI: <http://www.opengis.net/def/wkss/OGC/1.0/GoogleCRS84Quad>

This WKSS has been defined to allow quadtree pyramids in CRS84. The scale denominator is only accurate near the equator.

Table C.3 – Definition of Well-known scale set GoogleCRS84Quad

| CRS | SCALE DENOMINATOR | CELL SIZE (DEGREES) |
|---|-------------------------|---------------------------------|
| | 559,082,264. 0287178 | 1.406250000000000 |
| | 279,541,132. 0143589 | 0.703125000000000 |
| | 139,770,566. 0071794 | 0.351562500000000 |
| | 69,885,283. 00358972 | 0.175781250000000 |
| | 34,942,641. 50179486 | 8.78906250000000 × 10^{-2} |
| | 17,471,320. 75089743 | 4.39453125000000 × 10^{-2} |
| | 8,735,660. 375448715 | 2.19726562500000 × 10^{-2} |
| | 4,367,830. 187724357 | 1.09863281250000 × 10^{-2} |
| http://www.opengis.net/def/crs/OGC/1.3/CRS84 | 2,183,915. 093862179 | 5.49316406250000 × 10^{-3} |
| | 1,091,957. 546931089 | 2.74658203125000 × 10^{-3} |
| | 545,978. 7734655447 | 1.37329101562500 × 10^{-3} |
| | 272,989. 3867327723 | 6.86645507812500 × 10^{-4} |
| | 136,494. 6933663862 | 3.43322753906250 × 10^{-4} |
| | 68,247. 34668319309 | 1.71661376953125 × 10^{-4} |
| | 34,123. 67334159654 | 8.58306884765625 × 10^{-5} |
| | 17,061. 83667079827 | 4.29153442382812 × 10^{-5} |
| | 8530. 918335399136 | 2.14576721191406 × 10^{-5} |

| CRS | SCALE DENOMINATOR | CELL SIZE (DEGREES) |
|-----|-----------------------|---------------------------------|
| | 4265. 459167699568 | 1.07288360595703 × 10^{-5} |
| | 2132. 729583849784 | 5.36441802978516 × 10^{-6} |

NOTE 1: The first scale denominator allows representation of the whole world in a single tile of 256×256 cells, where 128 lines of the tile are left blank. The latter is the reason why in the Annex D “World CRS84 Quad TileMatrixSet definition” this level is not used. The next level allows representation of the whole world in 2×1 tiles of 256×256 cells and so on in powers of 2.

NOTE 2: Selecting the word “Google” for this WKSS id is maintained for backwards compatibility even if the authors recognize that it was an unfortunate selection and might result in confusion since the “Google-like” tiles do not use CRS84.

C.4. GoogleMapsCompatible

URI: <http://www.opengis.net/def/wkss/OGC/1.0/GoogleMapsCompatible>

This well-known scale set has been defined to be compatible with many mass marked implementations such as Google Maps, Microsoft Bing Maps (formerly Microsoft Live Maps) and Open Street Map tiles. The scale denominator and cell size are only accurate near the equator.

Table C.4 – Definition of Well-known scale set GoogleMapsCompatible

| CRS | ZOOM LEVEL NAME | SCALE DENOMINATOR | CELL SIZE (M) |
|---|-----------------|-------------------------|--------------------|
| http://www.opengis.net/def/crs/EPSG/0/3857 WGS 84 / Pseudo-Mercator | 0 | 559,082,264. 0287178 | 156,543.0339280410 |
| | 1 | 279,541,132. 0143589 | 78,271.51696402048 |
| | 2 | 139,770,566. 0071794 | 39,135.75848201023 |
| | 3 | 69,885,283. 00358972 | 19,567.87924100512 |
| | 4 | 34,942,641. 50179486 | 9783.939620502561 |
| | 5 | 17,471,320. 75089743 | 4891.969810251280 |

| CRS | ZOOM LEVEL NAME | SCALE DENOMINATOR | CELL SIZE (M) |
|-----|-----------------|-------------------------|--------------------------|
| | 6 | 8,735,660. 375448715 | 2445.984905125640 |
| | 7 | 4,367,830. 187724357 | 1222.992452562820 |
| | 8 | 2,183,915. 093862179 | 611.4962262814100 |
| | 9 | 1,091,957. 546931089 | 305.7481131407048 |
| | 10 | 545,978. 7734655447 | 152.8740565703525 |
| | 11 | 272,989. 3867327723 | 76.43702828517624 |
| | 12 | 136,494. 6933663862 | 38.21851414258813 |
| | 13 | 68,247. 34668319309 | 19.10925707129406 |
| | 14 | 34,123. 67334159654 | 9.554628535647032 |
| | 15 | 17,061. 83667079827 | 4.777314267823516 |
| | 16 | 8530. 918335399136 | 2.388657133911758 |
| | 17 | 4265. 459167699568 | 1.194328566955879 |
| | 18 | 2132. 729583849784 | 0.5971642834779395 |
| | 19 | 1066. 364791924892 | 0.2985821417389697 |
| | 20 | 533. 1823959624460 | 0.1492910708694849 |
| | 21 | 266. 5911979812230 | 0.07464553543474244 |
| | 22 | 133. 2955989906115 | 0.03732276771737122 |
| | 23 | 66. 64779949530575 | 0.01866138385868561 |
| | 24 | 33. 32389974765287 | 0. 009330691929342805 |

NOTE: Level 0 allows representing most of the world (limited to latitudes between approximately ± 85 degrees) in a single tile of 256×256 cells (Mercator projection cannot cover the whole world because mathematically the poles are at infinity). The next level represents most of the world in 2×2 tiles of 256×256 cells and so on in powers of 2.

C.5. WorldMercatorWGS84

URI: <http://www.opengis.net/def/wkss/OGC/1.0/WorldMercatorWGS84>

This well-known scale set has been defined as similar to Google Maps and Microsoft Bing Maps but using the WGS84 ellipsoid. The scale denominator and cell size are only accurate near the equator.

Table C.5 – Definition of Well-known scale set WorldMercatorWGS84

| CRS | ZOOM LEVEL NAME | SCALE DENOMINATOR | CELL SIZE (M) |
|--|-----------------|--------------------------|-----------------------|
| | 0 | 559,082,264. 02871774 | 156,543. 033928040 |
| | 1 | 279,541,132. 01435887 | 78,271. 5169640205 |
| | 2 | 139,770,566. 00717943 | 39,135. 7584820102 |
| | 3 | 69,885,283. 003589718 | 19,567. 8792410051 |
| | 4 | 34,942,641. 501794859 | 9783. 93962050256 |
| http://www.opengis.net/def/crs/EPSC/0/3395 WGS 84 / World Mercator | 5 | 17,471,320. 750897429 | 4891. 96988102512 |
| | 6 | 8,735,660. 3754487147 | 2445. 98490512564 |
| | 7 | 4,367,830. 1877243573 | 1222. 99245256282 |
| | 8 | 2,183,915. 0938621786 | 611. 496226281410 |
| | 9 | 1,091,957. 5469310893 | 305. 748113140705 |
| | 10 | 545,978. 77346554467 | 152. 874056570352 |

| CRS | ZOOM LEVEL NAME | SCALE DENOMINATOR | CELL SIZE (M) |
|-----|-----------------|-------------------------|----------------------|
| | 11 | 272,989. 38673277233 | 76. 4370282851762 |
| | 12 | 136,494. 69336638616 | 38. 2185141425881 |
| | 13 | 68,247. 346683193084 | 19. 1092570712940 |
| | 14 | 34,123. 673341596542 | 9. 55462853564703 |
| | 15 | 17,061. 836670798271 | 4. 77731426782351 |
| | 16 | 8530. 9183353991355 | 2. 38865713391175 |
| | 17 | 4265. 4591676995677 | 1. 19432856695587 |
| | 18 | 2132. 7295838497838 | 0. 59716428347793 |
| | 19 | 1066. 3647919248919 | 0. 29858214173896 |
| | 20 | 533. 18239596244597 | 0. 14929107086948 |
| | 21 | 266. 59119798122298 | 0. 07464553543474 |
| | 22 | 133. 29559899061149 | 0. 03732276771737 |
| | 23 | 66. 647799495305746 | 0. 01866138385868 |
| | 24 | 33. 323899747652873 | 0. 00933069192934 |

NOTE 1: Level 0 allows representing most of the world (limited to latitudes between approximately ± 85 degrees) in a single tile of 256×256 cells (Mercator projection cannot cover the whole world because mathematically the poles are at infinity). The next level represents most of the world in 2×2 tiles of 256×256 cells and so on in powers of 2.

NOTE 2: Mercator projection distorts the cell size closer to the poles. The cell sizes provided here are only valid next to the equator.

NOTE 3: The scales and cell sizes of *WorldMercatorWGS84* and *GoogleMapsCompatible* are identical, but the two WKSS reference a different CRS. This *WorldMercatorWGS84* WKSS was introduced in the first version of this standard and not present in the WMTS 1.0.0 specifications Annex E. However, WKSS are obsolete and not required to define a TileMatrixSet, so the

introduction of this new WKSS was not necessary to define the *WorldMercatorWGS84Quad* TileMatrixSet.

D

ANNEX D (INFORMATIVE) COMMON TILERMATRIXSET DEFINITIONS

ANNEX D (INFORMATIVE) COMMON TILEMATRIXSET DEFINITIONS

This Annex includes some definitions for TileMatrixSets that are commonly used.

D.1. WebMercatorQuad

URI: <http://www.opengis.net/def/tilematrixset/OGC/1.0/WebMercatorQuad>

Table D.1 – Definition of the WebMercatorQuad TileMatrixSet

CRS: <http://www.opengis.net/def/crs/EPSG/0/3857>, WGS 84 / Pseudo-Mercator

BBOX LowerLeft: -20,037,508.3427892, -20,037,508.3427892 (lat/long: -85.0511287798, -180)

BBOX UpperRight: 20,037,508.3427892, 20,037,508.3427892 (lat/long: 85.0511287798, 180)

WellKnownScaleSet: <http://www.opengis.net/def/wkss/OGC/1.0/GoogleMapsCompatible>

PointOfOrigin: -20,037,508.3427892, 20,037,508.3427892

TileWidth: 256

TileHeight: 256

| TileMatrix id | Scale Denominator | Cell Size (m) | Matrix Width | Matrix Height |
|---------------|-------------------------|------------------------|--------------|---------------|
| 0 | 559,082,264. 0287178 | 156,543. 0339280410 | 1 | 1 |
| 1 | 279,541,132. 0143589 | 78,271. 51696402048 | 2 | 2 |
| 2 | 139,770,566. 0071794 | 39,135. 75848201023 | 4 | 4 |
| 3 | 69,885,283. 00358972 | 19,567. 87924100512 | 8 | 8 |
| 4 | 34,942,641. 50179486 | 9783.939620502561 | 16 | 16 |
| 5 | 17,471,320. 75089743 | 4891.969810251280 | 32 | 32 |

| | | | | |
|----|-------------------------|------------------------|------------|------------|
| 6 | 8,735,660. 375448715 | 2445.984905125640 | 64 | 64 |
| 7 | 4,367,830. 187724357 | 1222.992452562820 | 128 | 128 |
| 8 | 2,183,915. 093862179 | 611.4962262814100 | 256 | 256 |
| 9 | 1,091,957. 546931089 | 305.7481131407048 | 512 | 512 |
| 10 | 545,978. 7734655447 | 152.8740565703525 | 1024 | 1024 |
| 11 | 272,989. 3867327723 | 76.43702828517624 | 2048 | 2048 |
| 12 | 136,494. 6933663862 | 38.21851414258813 | 4096 | 4096 |
| 13 | 68,247. 34668319309 | 19.10925707129406 | 8192 | 8192 |
| 14 | 34,123. 67334159654 | 9.554628535647032 | 16,384 | 16,384 |
| 15 | 17,061. 83667079827 | 4.777314267823516 | 32,768 | 32,768 |
| 16 | 8530. 918335399136 | 2.388657133911758 | 65,536 | 65,536 |
| 17 | 4265. 459167699568 | 1.194328566955879 | 131,072 | 131,072 |
| 18 | 2132. 729583849784 | 0. 5971642834779395 | 262,144 | 262,144 |
| 19 | 1066.36479192489 | 0. 2985821417389700 | 524,288 | 524,288 |
| 20 | 533.182395962445 | 0. 1492910708694850 | 1,048,576 | 1,048,576 |
| 21 | 266.591197981222 | 0. 0746455354347424 | 2,097,152 | 2,097,152 |
| 22 | 133.295598990611 | 0. 0373227677173712 | 4,194,304 | 4,194,304 |
| 23 | 66.6477994953056 | 0. 0186613838586856 | 8,388,608 | 8,388,608 |
| 24 | 33.3238997476528 | 0. 0093306919293428 | 16,777,216 | 16,777,216 |

One can define an arbitrary number of zoom levels and does not need to include all the zoom levels defined here. Here, 25 zoom levels are illustrated.

NOTE 1: Mercator projection distorts the cell size the closer to the poles. The cell sizes provided here are only valid next to the equator in the direction E-W.

NOTE 2: The EPSG CRS code 3857 is the official code for Web Mercator. An unofficial code "900913" (GOOGLE spelled with numbers) was initially assigned and is sometimes still used.

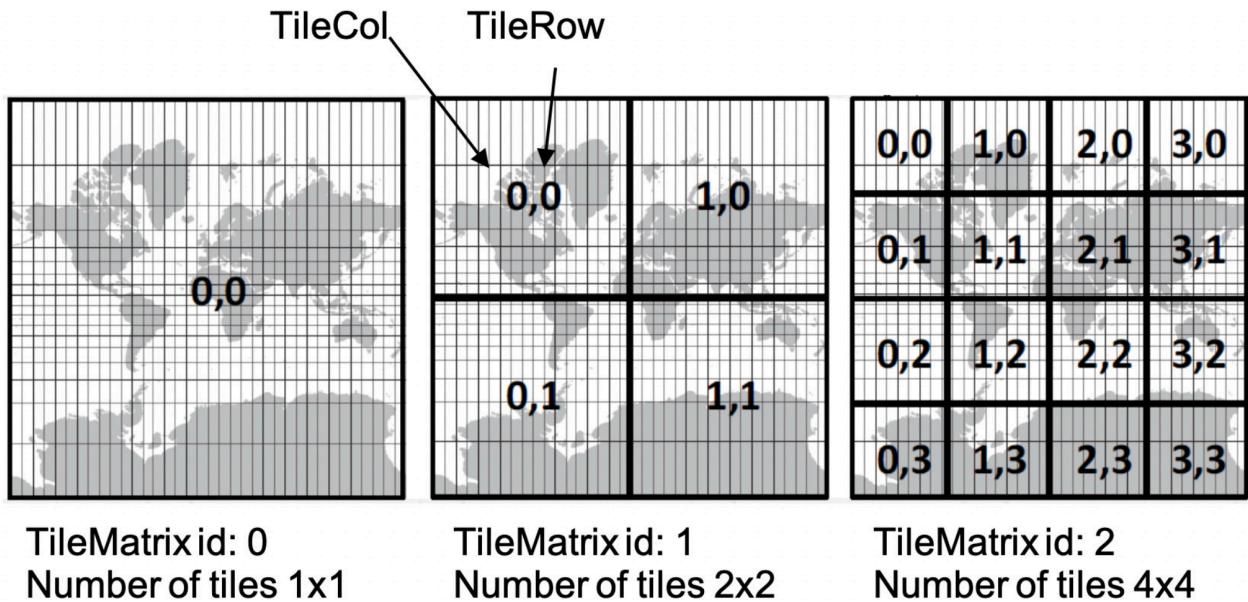


Figure D.1 – The 3 first Tile Matrix of the WebMercatorQuad TileMatrixSet (Source CCA)

This tile matrix set is the most used tile matrix set in the mass market: for example, by Google Maps, Microsoft Bing Maps and OpenStreetMap tiles. Nevertheless, it has been long criticized because it is based on a spherical Mercator instead of an ellipsoid. The use of WebMercatorQuad should be limited to visualization. Any additional use (including distance measurements, routing etc.) needs to use the Mercator spherical expressions to transform the coordinate to an appropriate CRS first.

NOTE 3: For example, the EPSG database version 8.9 says about the 3857: "Uses spherical development of ellipsoidal coordinates. Relative to WGS 84 / World Mercator (CRS code 3395) errors of 0.7 percent in scale and differences in northing of up to 43km in the map (equivalent to 21km on the ground) may arise."

NOTE 4: The use of Web Mercator can generate erroneous geospatial positioning information poses an unacceptable risk to global safety of navigation activities, and department of defense, intelligence community, and allied partner systems, missions, and operations that require accurate and precise positioning and navigation information." The use of WorldMercatorWGS84Quad is recommended.

D.2. WorldCRS84Quad

URI: <http://www.opengis.net/def/tilematrixset/OGC/1.0/WorldCRS84Quad>

D.2.1. Variant 1: World CRS84 Quad (recommended)

This Tile Matrix Set defines tiles in the Equirectangular Plate Carrée projection in the CRS84 CRS for the whole world.

Table D.2 – Definition of the WorldCRS84Quad TileMatrixSet

CRS: <http://www.opengis.net/def/crs/OGC/1.3/CRS84>, CRS84

BBOX LowerLeft: -180, -90

BBOX UpperRight: 180, 90

WellKnownScaleSet: <http://www.opengis.net/def/wkss/OGC/1.0/GoogleCRS84Quad>

PointOfOrigin: -180, 90

TileWidth: 256

TileHeight: 256

| TileMatrix id | Scale Denominator | Cell Size (degrees) (true at the equator) | Matrix Width | Matrix Height |
|---------------|-------------------------|---|--------------|---------------|
| 0 | 279,541,132. 0143589 | 0.703125000000000 | 2 | 1 |
| 1 | 139,770,566. 0071794 | 0.351562500000000 | 4 | 2 |
| 2 | 69,885,283. 00358972 | 0.175781250000000 | 8 | 4 |
| 3 | 34,942,641. 50179486 | $8.7890625000000 \times 10^{-2}$ | 16 | 8 |
| 4 | 17,471,320. 75089743 | $4.3945312500000 \times 10^{-2}$ | 32 | 16 |
| 5 | 8,735,660. 375448715 | $2.1972656250000 \times 10^{-2}$ | 64 | 32 |
| 6 | 4,367,830. 187724357 | $1.0986328125000 \times 10^{-2}$ | 128 | 64 |
| 7 | 2,183,915. 093862179 | $5.4931640625000 \times 10^{-3}$ | 256 | 128 |
| 8 | 1,091,957. 546931089 | $2.7465820312500 \times 10^{-3}$ | 512 | 256 |
| 9 | 545,978. 7734655447 | $1.37329101562500 \times 10^{-3}$ | 1024 | 512 |

| | | | | |
|----|------------------------|-----------------------------------|------------|-----------|
| 10 | 272,989. 3867327723 | $6.86645507812500 \times 10^{-4}$ | 2048 | 1024 |
| 11 | 136,494. 6933663862 | $3.43322753906250 \times 10^{-4}$ | 4096 | 2048 |
| 12 | 68,247. 34668319309 | $1.71661376953125 \times 10^{-4}$ | 8192 | 4096 |
| 13 | 34,123. 67334159654 | $8.58306884765625 \times 10^{-5}$ | 16,384 | 8192 |
| 14 | 17,061. 83667079827 | $4.29153442382812 \times 10^{-5}$ | 32,768 | 16,384 |
| 15 | 8530. 918335399136 | $2.14576721191406 \times 10^{-5}$ | 65,536 | 32,768 |
| 16 | 4265. 459167699568 | $1.07288360595703 \times 10^{-5}$ | 131,072 | 65,536 |
| 17 | 2132. 729583849784 | $5.36441802978516 \times 10^{-6}$ | 262,144 | 131,072 |
| 18 | 1066. 36479192489 | $2.68220901489258 \times 10^{-6}$ | 524,288 | 262,144 |
| 19 | 533. 182395962445 | $1.34110450744629 \times 10^{-6}$ | 1,048,576 | 524,288 |
| 20 | 266. 591197981222 | $6.70552253723144 \times 10^{-7}$ | 2,097,152 | 1,048,576 |
| 21 | 133. 295598990611 | $3.35276126861572 \times 10^{-7}$ | 4,194,304 | 2,097,152 |
| 22 | 66. 6477994953056 | $1.67638063430786 \times 10^{-7}$ | 8,388,608 | 4,194,304 |
| 23 | 33. 3238997476528 | $8.3819031715393 \times 10^{-8}$ | 16,777,216 | 8,388,608 |

One can define an arbitrary number of zoom levels and does not need to include all the ones defined here. Here, 18 zoom levels are illustrated.



Figure D.2 – Tile Matrix Id 1 (2x1 tiles) of the WorldCRS84Quad TileMatrixSet (Source: INSPIRE technical guidance)

NOTE 1: The zoom level identifiers in this TileMatrixSet do not correspond to the same scale values in Annex E.3 of WMTS 1.0. In this TileMatrixSet, the TileMatrix with identifier “-1” has only one tile with 128 lines left blank. For that reason, many implementers do not want to offer this level (including the INSPIRE technical guidance) and prefer to start with a TileMatrix that represents the world with just 2 tiles (one for the negative longitudes and one for the positive longitudes).

NOTE 2: The scale denominators for this TileMatrixSet and WorldMercatorWGS84Quad and WebMercatorQuad are the same but the identifiers are displaced by one. This might generate confusion.

NOTE 3: For INSPIRE: The Technical Guidance for the implementation of INSPIRE View Services defines a TileMatrixSet called InspireCRS84Quad that is identical to this one [32]. Note that the current version of the INSPIRE Technical Guidance cited in the Bibliography Annex could accidentally generate confusion because it is comparing a GoogleCRS84Quad (that is a well-known scale set name) with the InspireCRS84Quad (that is a TileMatrixSet definition that does not link to any WKSS).

D.2.2. Variant 2: World EPSG:4326 Quad

Despite what is stated in Clause 6.2.1.1, some implementers prefer to define the previous TileMatrixSet using the CRS <http://www.opengis.net/def/crs/EPSC/0/4326>. The definition is the same as the variant defined using <http://www.opengis.net/def/crs/OGC/1.3/CRS84> except that CRS coordinates are expressed in latitude, longitude order, affecting the *PointOfOrigin* and the *BoundingBox* encoding only. For most practical purposes, both variations are equivalent because a TileMatrixSet primarily defines the tiling structure as well as the scale/resolution at each tile matrix, rather than how the data within each tile is stored. For many raster and

vector tiles formats, CRS84 and EPSG:4326 are equivalent as a particular axis order is enforced. Additional parameters to an API for example could also override the default axis order by specifying the CRS as either CRS84 or EPSG:4326.

If possible, defining it in terms of <http://www.opengis.net/def/crs/OGC/1.3/CRS84> is recommended instead of this variation, because it uses the CRS consistent with the TileMatrixSet URI. However, we introduce it here to clarify how an implementation based on EPSG:4326 should look like and avoid confusion.

This Tile Matrix Set defines tiles in the Equirectangular Plate Carrée projection in the EPSG:4326 CRS for the whole world.

Table D.3 – Definition of the WorldCRS84Quad TileMatrixSet (EPSG:4326)

CRS: <http://www.opengis.net/def/crs/EPSC/0/4326>, EPSG:4326

BBOX LowerLeft: -90, -180

BBOX UpperRight: 90, 180

WellKnownScaleSet: <http://www.opengis.net/def/wkss/OGC/1.0/GoogleCRS84Quad>

PointOfOrigin: 90, -180

TileWidth: 256

TileHeight: 256

| TileMatrix id | Scale Denominator | Cell Size (degrees) (true at the equator) | Matrix Width | Matrix Height |
|---------------|-------------------------|---|--------------|---------------|
| 0 | 279,541,132. 0143589 | 0.7031250000000000 | 2 | 1 |
| 1 | 139,770,566. 0071794 | 0.3515625000000000 | 4 | 2 |
| 2 | 69,885,283. 00358972 | 0.1757812500000000 | 8 | 4 |
| 3 | 34,942,641. 50179486 | $8.78906250000000 \times 10^{-2}$ | 16 | 8 |
| 4 | 17,471,320. 75089743 | $4.39453125000000 \times 10^{-2}$ | 32 | 16 |
| 5 | 8,735,660. 375448715 | $2.19726562500000 \times 10^{-2}$ | 64 | 32 |
| 6 | 4,367,830. 187724357 | $1.09863281250000 \times 10^{-2}$ | 128 | 64 |
| 7 | 2,183,915. 093862179 | $5.49316406250000 \times 10^{-3}$ | 256 | 128 |
| 8 | 1,091,957. 546931089 | $2.74658203125000 \times 10^{-3}$ | 512 | 256 |
| 9 | 545,978. 7734655447 | $1.37329101562500 \times 10^{-3}$ | 1024 | 512 |

| | | | | |
|----|------------------------|-----------------------------------|------------|-----------|
| 10 | 272,989. 3867327723 | $6.86645507812500 \times 10^{-4}$ | 2048 | 1024 |
| 11 | 136,494. 6933663862 | $3.43322753906250 \times 10^{-4}$ | 4096 | 2048 |
| 12 | 68,247. 34668319309 | $1.71661376953125 \times 10^{-4}$ | 8192 | 4096 |
| 13 | 34,123. 67334159654 | $8.58306884765625 \times 10^{-5}$ | 16,384 | 8192 |
| 14 | 17,061. 83667079827 | $4.29153442382812 \times 10^{-5}$ | 32,768 | 16,384 |
| 15 | 8530. 918335399136 | $2.14576721191406 \times 10^{-5}$ | 65,536 | 32,768 |
| 16 | 4265. 459167699568 | $1.07288360595703 \times 10^{-5}$ | 131,072 | 65,536 |
| 17 | 2132. 729583849784 | $5.36441802978516 \times 10^{-6}$ | 262,144 | 131,072 |
| 18 | 1066. 36479192489 | $2.68220901489258 \times 10^{-6}$ | 524,288 | 262,144 |
| 19 | 533. 182395962445 | $1.34110450744629 \times 10^{-6}$ | 1,048,576 | 524,288 |
| 20 | 266. 591197981222 | $6.70552253723144 \times 10^{-7}$ | 2,097,152 | 1,048,576 |
| 21 | 133. 295598990611 | $3.35276126861572 \times 10^{-7}$ | 4,194,304 | 2,097,152 |
| 22 | 66. 6477994953056 | $1.67638063430786 \times 10^{-7}$ | 8,388,608 | 4,194,304 |
| 23 | 33. 3238997476528 | $8.3819031715393 \times 10^{-8}$ | 16,777,216 | 8,388,608 |

D.3. WorldMercatorWGS84Quad

URI: <http://www.opengis.net/def/tilematrixset/OGC/1.0/WorldMercatorWGS84Quad>

Table D.4 – Definition of the WorldMercatorWGS84Quad TileMatrixSet

CRS: <http://www.opengis.net/def/crs/EPSG/0/3395>, WGS 84 / World-Mercator

BBOX LowerLeft: -20,037,508.3427892, -20,037,508.3427892 (lat, long: -85.08405903, -180)

BBOX UpperRight: 20,037,508.3427892, 20,037,508.3427892 (lat, long: 85.08405903, 180)

WellKnownScaleSet: <http://www.opengis.net/def/wkss/OGC/1.0/WorldMercatorWGS84>

PointOfOrigin: -20,037,508.3427892, 20,037,508.3427892

TileWidth: 256

TileHeight: 256

| Tile Matrix id | Scale Denominator | Cell Size (m) (true at the equator) | Cell Size (m) at latitude ±31. 0606963703645 | Matrix Width | Matrix Height |
|----------------|--------------------------|-------------------------------------|--|--------------|---------------|
| 0 | 559,082,264. 02871774 | 156,543. 033928040 | 134,217.728 | 1 | 1 |
| 1 | 279,541,132. 01435887 | 78,271. 5169640205 | 67,108.864 | 2 | 2 |
| 2 | 139,770,566. 00717943 | 39,135. 7584820102 | 33,554.432 | 4 | 4 |
| 3 | 69,885,283. 003589718 | 19,567. 8792410051 | 16,777.216 | 8 | 8 |
| 4 | 34,942,641. 501794859 | 9783. 93962050256 | 8388.608 | 16 | 16 |
| 5 | 17,471,320. 750897429 | 4891. 96988102512 | 4194.304 | 32 | 32 |
| 6 | 8,735,660. 3754487147 | 2445. 98490512564 | 2097.152 | 64 | 64 |
| 7 | 4,367,830. 1877243573 | 1222. 99245256282 | 1048.576 | 128 | 128 |
| 8 | 2,183,915. 0938621786 | 611. 496226281410 | 524.288 | 256 | 256 |
| 9 | 1,091,957. 5469310893 | 305. 748113140705 | 262.144 | 512 | 512 |
| 10 | 545,978. 77346554467 | 152. 874056570352 | 131.072 | 1024 | 1024 |
| 11 | 272,989. 38673277233 | 76. 4370282851762 | 65.536 | 2048 | 2048 |
| 12 | 136,494. 69336638616 | 38. 2185141425881 | 32.768 | 4096 | 4096 |
| 13 | 68,247. 346683193084 | 19. 1092570712940 | 16.384 | 8192 | 8192 |
| 14 | 34,123. 673341596542 | 9. 55462853564703 | 8.192 | 16,384 | 16,384 |
| 15 | 17,061. 836670798271 | 4. 77731426782351 | 4.096 | 32,768 | 32,768 |
| 16 | 8530. 9183353991355 | 2. 38865713391175 | 2.048 | 65,536 | 65,536 |

| | | | | | |
|----|------------------------|----------------------|-------|------------|------------|
| 17 | 4265. 4591676995677 | 1. 19432856695587 | 1.024 | 131.072 | 131.072 |
| 18 | 2132. 7295838497838 | 0. 59716428347793 | 0.512 | 262,144 | 262,144 |
| 19 | 1066. 3647919248919 | 0. 29858214173896 | 0.256 | 524,288 | 524,288 |
| 20 | 533. 18239596244597 | 0. 14929107086948 | 0.128 | 1,048,576 | 1,048,576 |
| 21 | 266. 59119798122298 | 0. 07464553543474 | 0.064 | 2,097,152 | 2,097,152 |
| 22 | 133. 29559899061149 | 0. 03732276771737 | 0.032 | 4,194,304 | 4,194,304 |
| 23 | 66. 647799495305746 | 0. 01866138385868 | 0.016 | 8,388,608 | 8,388,608 |
| 24 | 33. 323899747652873 | 0. 00933069192934 | 0.008 | 16,777,216 | 16,777,216 |

One can define an arbitrary number of zoom levels and does not need to include all the zoom levels defined here. Here, 25 zoom levels are illustrated.

This Tile Matrix Set looks similar to the previous one (Web Mercator Quad) but this one is based on an ellipsoidal Mercator. Please note that the most northern latitude cover by this one is 85.08405903 (different from Web Mercator).



Figure D.3 – Tile Matrix Id 1 (red lines; 2x2 tiles) and 3 (blue lines; 8x8 tiles) of the WorldMercatorWGS84Quad TileMatrixSet (Source NGA)

NOTE 1: The Geomatics Office at the National Geospatial Intelligence Agency (NGA), a part of the US Department of Defense (DoD), reminds the community to use DoD approved World Geodetic System 1984 (WGS 84) applications for all mission critical activities and encourages the use of WGS84 based tile matrix sets like this one and discourages the use of Web Mercator tiles based on Web Mercator such as WebMercatorQuad.

NOTE 2: The NGA Geomatics Office recommends the use of Universal zoom-levels scale set that are defined as true cell size at ± 31.0606963703645 degrees of latitude that implies a scale reduction at the equator of 0.857385503731176. This standard recommends the use of scale denominators at the equator for convenience.

D.4. Universal Transverse Mercator WGS84 Quad family (UTM##WGS84Quad)

URI: <http://www.opengis.net/def/tilematrixset/OGC/1.0/UTM##WGS84Quad>

The Universal Transversal Mercator (a special case of transverse Mercator), divides the world into 60 zones by longitude. No single zone would make a global or near-global map. Therefore, this definition is a family of 60 TileMatrixSets in a single table.

Table D.5 – Definition of the UTM##WGS84Quad TileMatrixSets

##: it is a number that goes from 01 to 60

CRSs: [<http://www.opengis.net/def/crs/EPSG/0/32601>, <http://www.opengis.net/def/crs/EPSG/0/32660>] WGS 84 / UTM

BBOX LowerLeft: -9,501,965.72931276, -20,003,931.4586255; lat, long: -180, -62+(##-31)*6

BBOX UpperRight: 10,501,965.7293128, 20,003,931.4586255 (lat, long: 180, 68+(##-31)*6)

WellKnownScaleSet: N/A

PointOfOrigin: -9,501,965.72931276, 20,003,931.4586255

TileWidth: 256

TileHeight: 256

| Tile Matrix id | Scale Denominator | Cell Size (m) along the central meridian | Cell Size (m) at a point on the Equator and at longitude $\pm 30.70052433281 \cdot 31^{\circ}6'$ | Matrix Width | Matrix Height |
|----------------|--------------------|--|--|--------------|---------------|
| 1 | 279,072,704.500914 | 78,140.3572602559 | 67,108.864 | 1 | 2 |
| 2 | 139,536,352.250457 | 39,070.178630128 | 33,554.432 | 2 | 4 |
| 3 | 69,768,176.1252285 | 19,535.089315064 | 16,777.216 | 4 | 8 |
| 4 | 34,884,088.0626143 | 9767.5446575319 | 8388.608 | 8 | 16 |
| 5 | 17,442,044.0313071 | 4883.772328766 | 4194.304 | 16 | 32 |
| 6 | 8,721,022.01565356 | 2441.886164383 | 2097.152 | 32 | 64 |
| 7 | 4,360,511.00782678 | 1220.9430821915 | 1048.576 | 64 | 128 |

| | | | | | |
|----|------------------------|-------------------------------------|---------|-----------|------------|
| 8 | 2,180,255. 50391339 | 610.471541095749 | 524.288 | 128 | 256 |
| 9 | 1,090,127. 75195670 | 305.235770547875 | 262.144 | 256 | 512 |
| 10 | 545,063. 875978348 | 152.617885273937 | 131.072 | 512 | 1024 |
| 11 | 272,531. 937989174 | 76.3089426369687 | 65.536 | 1024 | 2048 |
| 12 | 136,265. 968994587 | 38.1544713184843 | 32.768 | 2048 | 4096 |
| 13 | 68,132. 9844972935 | 19.0772356592422 | 16.384 | 4096 | 8192 |
| 14 | 34,066. 4922486467 | 9.53861782962109 | 8.192 | 8192 | 16,384 |
| 15 | 17,033. 2461243234 | 4.76930891481054 | 4.096 | 16,384 | 32,768 |
| 16 | 8516. 62306216168 | 2.38465445740527 | 2.048 | 32,768 | 65,536 |
| 17 | 4258. 31153108084 | 1.19232722870264 | 1.024 | 65,536 | 131.072 |
| 18 | 2129. 15576554042 | 0. 596163614351318 | 0.512 | 131.072 | 262,144 |
| 19 | 1064. 57788277021 | 0. 298081807175659 | 0.256 | 262,144 | 524,288 |
| 20 | 532. 288941385105 | 0. 149040903587829 | 0.128 | 524,288 | 1,048,576 |
| 21 | 266. 144470692553 | 0. 0745204517939147 | 0.064 | 1,048,576 | 2,097,152 |
| 22 | 133. 072235346276 | 0. 0372602258969574 | 0.032 | 2,097,152 | 4,194,304 |
| 23 | 66. 5361176731382 | 0. 0186301129484787 | 0.016 | 4,194,304 | 8,388,608 |
| 24 | 33. 2680588365691 | 0. 0093150564742393 ² | 0.008 | 8,388,608 | 16,777,216 |

One can define an arbitrary number of zoom levels and does not need to include all the zoom levels defined here. Here, 24 zoom levels are illustrated.

NOTE 1: The southern hemisphere ([<http://www.opengis.net/def/crs/EPSG/0/32701>, <http://www.opengis.net/def/crs/EPSG/0/32760>]) is covered by extending the UTM northern CRSs to the south in a way that the southern hemisphere CRSs are neither used nor needed.

NOTE 2: The UTM projection is supposed to be used in zones that are only 3 degrees apart from the central meridian forming 6-degree wide zones. In some parts of the world, it is useful to relax this limitation to cover a wider object (for example, Spain can be fully represented in UTM30 zone if the 3-degree limit is relaxed). The farther one goes from the central meridian, the more deformations are experienced in the projection. The top left corner of this tile matrix set has been defined 65 degrees apart of the central meridian to allow much more extreme cases, but it is highly recommended that applications limit themselves to the 6-degree wide central area and use TileMatrixSetLimits to define actual boundaries of the tile indices used in this area.

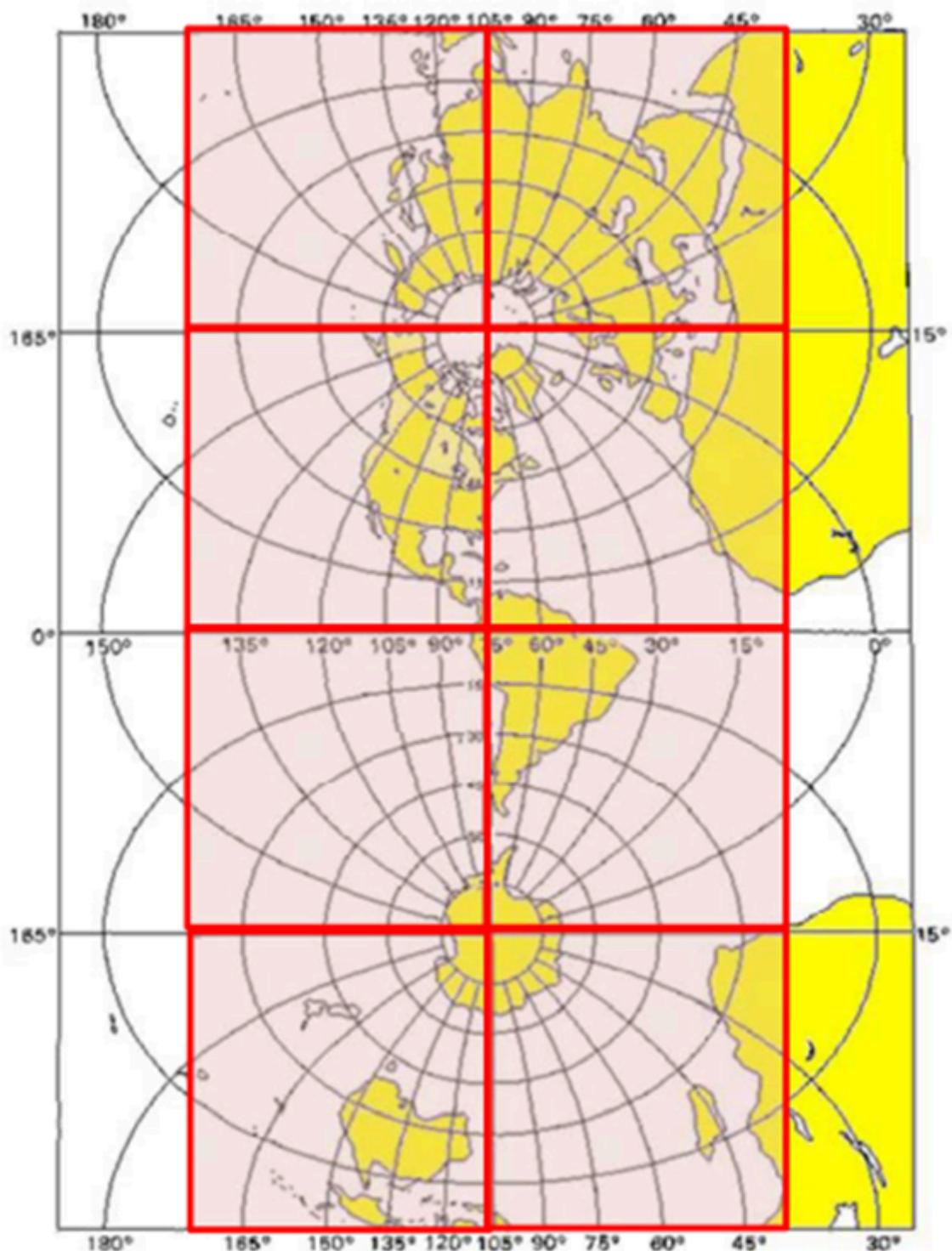


Figure D.4 – Tile Matrix Id 1 (dashed blue lines; 1x2 tiles) and 2 (red lines; 2x4 tiles) of the UTM18WGS84Quad TileMatrixSet (Source NGA)

NOTE 3: The NGA Geomatics Office recommends the use of Universal zoom-levels scale set that are defined as true cell size at ± 30.700524332812 degrees of longitude at both sides of the central meridian that implies a scale reduction at the central meridian of 0.85882463752355 . The tiles considering this scale are exactly the same than considering true

cell size at the equator and no scale reduction. This standard recommends the use of scale denominators at the equator for convenience.

D.5. Arctic Universal Polar Stereographic WGS 84 Quad (UPSArcticWGS84Quad)

URI: <http://www.opengis.net/def/tilematrixset/OGC/1.0/UPSArcticWGS84Quad>

It is difficult to find consensus in the geospatial community for what constitutes the “best” tile matrix set for the polar areas. Even if everyone agrees on using a polar stereographic, the election of the PointOfOrigin and scale denominators is almost arbitrary. This document presents the NGA recommendation for polar stereographic that allows for the representation of more than one hemisphere to 15 degrees into the opposite hemisphere and shares a common set of cell sizes with the WorldMercatorWGS84Quad and the UTM##WGS84Quad. The selection of a CRS for a polar stereographic is difficult and this document follows several criteria (see NOTE 2). In the end, the UPS North that is commonly used in conjunction with UTM was selected.

NOTE 1: In Mercator or Transversal Mercator projections the first scale denominator and top left corner are selected in a way that a single tile can cover all ranges of longitudes or latitudes respectively. Due to the nature of this projection, these criteria cannot be applied. The top left corner selection deeply depends on the application. The very distant top left corner was selected here to include as many applications as possible.

Table D.6 – Definition of the UPSArcticWGS84Quad TileMatrixSet

CRS: <http://www.opengis.net/def/crs/EPSG/0/5041>, WGS 84 Universal Polar Stereographic North

BBOX LowerLeft: -14,440,759.350252, -14,440,759.350252

BBOX UpperRight: 18,440,759.350252, 18,440,759.350252

WellKnownScaleSet: N/A

PointOfOrigin: -14,440,759.350252, 18,440,759.350252

TileWidth: 256

TileHeight: 256

| Tile Matrix id | Scale Denominator | Cell Size (m) (true at latitude ~81) | True Cell Size (m) at the pole (informative) | Matrix Width | Matrix Height |
|----------------|-------------------|--------------------------------------|--|--------------|---------------|
| 0 | 458,726,544.4 | 128,443.4324 | 129,218.7449 | 1 | 1 |
| 1 | 229,363,272.2 | 64,221.71621 | 64,609.37245 | 2 | 2 |
| 2 | 114,681,636.1 | 32,110.85811 | 32,304.68622 | 4 | 4 |

| | | | | | |
|----|---------------|--------------|--------------|------------|------------|
| 3 | 57,340,818.05 | 16,055.42905 | 16,152.34311 | 8 | 8 |
| 4 | 28,670,409.02 | 8027.714526 | 8076.171556 | 16 | 16 |
| 5 | 14,335,204.51 | 4013.857263 | 4038.085778 | 32 | 32 |
| 6 | 7,167,602.256 | 2006.928632 | 2019.042889 | 64 | 64 |
| 7 | 3,583,801.128 | 1003.464316 | 1009.521444 | 128 | 128 |
| 8 | 1,791,900.564 | 501.7321579 | 504.7607222 | 256 | 256 |
| 9 | 895,950.282 | 250.866079 | 252.3803611 | 512 | 512 |
| 10 | 447,975.141 | 125.4330395 | 126.1901806 | 1024 | 1024 |
| 11 | 223,987.5705 | 62.71651974 | 63.09509028 | 2048 | 2048 |
| 12 | 111,993.7852 | 31.35825987 | 31.54754514 | 4096 | 4096 |
| 13 | 55,996.89262 | 15.67912993 | 15.77377257 | 8192 | 8192 |
| 14 | 27,998.44631 | 7.839564967 | 7.886886285 | 16,384 | 16,384 |
| 15 | 13,999.22316 | 3.919782484 | 3.943443142 | 32,768 | 32,768 |
| 16 | 6999.611578 | 1.959891242 | 1.971721571 | 65,536 | 65,536 |
| 17 | 3499.805789 | 0.979945621 | 0.985860786 | 131.072 | 131.072 |
| 18 | 1749.902894 | 0.48997281 | 0.492930393 | 262,144 | 262,144 |
| 19 | 874.9514472 | 0.244986405 | 0.246465196 | 524,288 | 524,288 |
| 20 | 437.4757236 | 0.122493203 | 0.123232598 | 1,048,576 | 1,048,576 |
| 21 | 218.7378618 | 0.061246601 | 0.061616299 | 2,097,152 | 2,097,152 |
| 22 | 109.3689309 | 0.030623301 | 0.03080815 | 4,194,304 | 4,194,304 |
| 23 | 54.68446545 | 0.01531165 | 0.015404075 | 8,388,608 | 8,388,608 |
| 24 | 27.34223273 | 0.007655825 | 0.007702037 | 16,777,216 | 16,777,216 |

One can define an arbitrary number of zoom levels and does not need to include all the zoom levels defined here. Here, 25 zoom levels are illustrated.



Figure D.5 – Tile Matrix Id 0 (exterior line; 1×1 tile) and 1 (blank lines; 2×2 tiles) of the UPSArcticWGS84Quad TileMatrixSet (Source NGA)

NOTE 2: In practice, there are many polar stereographic CRS and it is difficult to prioritize one. On many occasions, the meridian of origin is selected in order to rotate the projection and allow a region to become more prominent. Examples are rotations emphasizing Greenland or Alaska. To be general, the 0 meridian of origin was selected. In addition, polar projections have a variety of standard parallels and here is selected 90N. In the UPS system, the North Pole is assigned the coordinates $x=2,000,000$, $y=2,000,000$.

NOTE 3: NGA has suggested also another TileMatrixSet called *sixteenth tile* that covers less area by having the *PointOfOrigin* at $2,110,189.837563$, $6,110,189.837563$, BBOX LowerLeft:

2,110,189.837562966, -2,110,189.837562966 and BBOX UpperRight: 6,110,189.837562966, 6,110,189.837562966. The same result can be achieved by using the TileMatrixSetLimits mechanism without having to define an entirely new TileMatrixSet.



Figure D.6 – Rotation of the meridian of origin to allow a region to become more prominent (a. EPSG:3995, Arctic WGS 84 Polar Stereographic, b. EPSG:3413 WGS 84 / NSIDC Polar Stereographic North, c. EPSG:5936 / Alaska Polar Stereographic). This TileMatrixSet has 0 rotation angle for the meridian of origin.

D.6. Antarctic Universal Polar Stereographic WGS84 Quad (UPSAntarcticWGS84Quad)

URI: <http://www.opengis.net/def/tilematrixset/OGC/1.0/UPSAntarcticWGS84Quad>

There is no consensus in the geospatial community for what constitutes the “best” tile matrix set for the polar stereographic projection. One reason for this is that the election of the PointOfOrigin and scale denominators is almost completely arbitrary. In this document, a TileMatrixSet identical to the Arctic one but with an Antarctic CRS was selected.

Table D.7 – Definition of the UPSAntarcticWGS84Quad TileMatrixSet

CRS: <http://www.opengis.net/def/crs/EPSC/0/5042>, WGS 84 Universal Polar Stereographic South
BBOX LowerLeft: -14,440,759.350252, -14,440,759.350252
BBOX UpperRight: 18,440,759.350252, 18,440,759.350252
WellKnownScaleSet: N/A
PointOfOrigin: -14,440,759.350252, 18,440,759.350252
TileWidth: 256
TileHeight: 256

| Tile Matrix id | Scale Denominator | Cell Size (m) (true at latitude ~-81) | True Cell Size (m) at the pole (informative) | Matrix Width | Matrix Height |
|----------------|-------------------|---------------------------------------|--|--------------|---------------|
| 0 | 458,726,544.4 | 128,443.4324 | 129,218.7449 | 1 | 1 |
| 1 | 229,363,272.2 | 64,221.71621 | 64,609.37245 | 2 | 2 |
| 2 | 114,681,636.1 | 32,110.85811 | 32,304.68622 | 4 | 4 |
| 3 | 57,340,818.05 | 16,055.42905 | 16,152.34311 | 8 | 8 |
| 4 | 28,670,409.02 | 8027.714526 | 8076.171556 | 16 | 16 |
| 5 | 14,335,204.51 | 4013.857263 | 4038.085778 | 32 | 32 |
| 6 | 7,167,602.256 | 2006.928632 | 2019.042889 | 64 | 64 |
| 7 | 3,583,801.128 | 1003.464316 | 1009.521444 | 128 | 128 |
| 8 | 1,791,900.564 | 501.7321579 | 504.7607222 | 256 | 256 |
| 9 | 895,950.282 | 250.866079 | 252.3803611 | 512 | 512 |
| 10 | 447,975.141 | 125.4330395 | 126.1901806 | 1024 | 1024 |
| 11 | 223,987.5705 | 62.71651974 | 63.09509028 | 2048 | 2048 |
| 12 | 111,993.7852 | 31.35825987 | 31.54754514 | 4096 | 4096 |
| 13 | 55,996.89262 | 15.67912993 | 15.77377257 | 8192 | 8192 |
| 14 | 27,998.44631 | 7.839564967 | 7.886886285 | 16,384 | 16,384 |
| 15 | 13,999.22316 | 3.919782484 | 3.943443142 | 32,768 | 32,768 |
| 16 | 6999.611578 | 1.959891242 | 1.971721571 | 65,536 | 65,536 |
| 17 | 3499.805789 | 0.979945621 | 0.985860786 | 131.072 | 131.072 |
| 18 | 1749.902894 | 0.48997281 | 0.492930393 | 262,144 | 262,144 |
| 19 | 874.9514472 | 0.244986405 | 0.246465196 | 524,288 | 524,288 |
| 20 | 437.4757236 | 0.122493203 | 0.123232598 | 1,048,576 | 1,048,576 |

| | | | | | |
|----|-------------|-------------|-------------|------------|------------|
| 21 | 218.7378618 | 0.061246601 | 0.061616299 | 2,097,152 | 2,097,152 |
| 22 | 109.3689309 | 0.030623301 | 0.03080815 | 4,194,304 | 4,194,304 |
| 23 | 54.68446545 | 0.01531165 | 0.015404075 | 8,388,608 | 8,388,608 |
| 24 | 27.34223273 | 0.007655825 | 0.007702037 | 16,777,216 | 16,777,216 |

One can define an arbitrary number of zoom levels and does not need to include all the zoom levels defined here. Here, 25 zoom levels are illustrated.

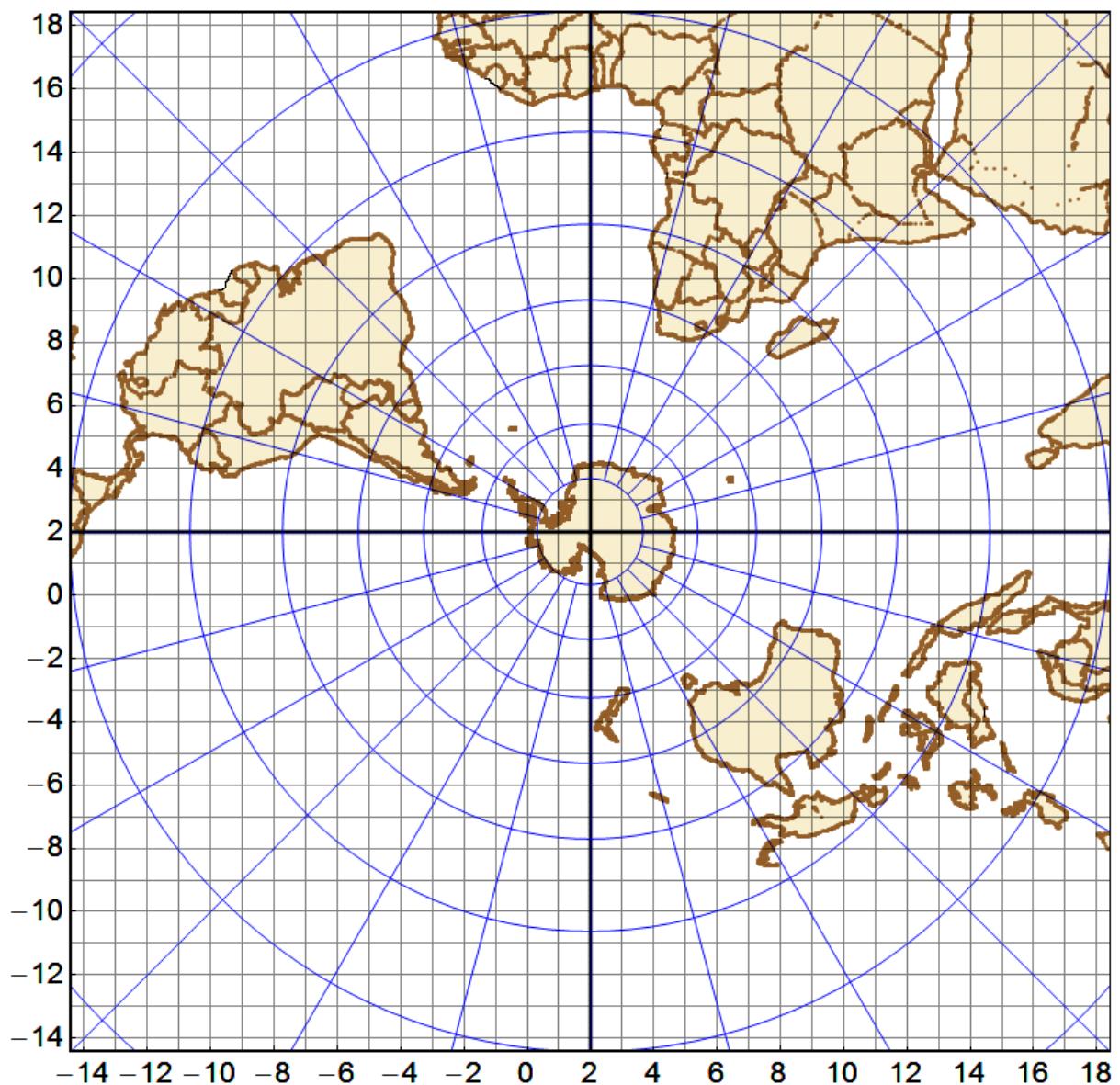


Figure D.7 – Tile Matrix Id 0 (exterior line; 1x1 tile) and 1 (black lines; 2x2 tiles) of the UPSAntarcticWGS84Quad TileMatrixSet (Source NGA)

D.7. European ETRS89 Lambert azimuthal equal-area Quad (EuropeanETRS89_LAEAQuad)

URI: http://www.opengis.net/def/tilematrixset/OGC/1.0/EuropeanETRS89_LAEAQuad

Table D.8 – Definition of the EuropeanETRS89_LAEAQuad TileMatrixSet

CRS: <http://www.opengis.net/def/crs/EPSG/0/3035>, ETRS89

BBOX LowerLeft: 1,000,000.0, 2,000,000.0

BBOX UpperRight: 5,500,000.0, 6,500,000.0

WellKnownScaleSet: N/A

PointOfOrigin: 5,500,000.0, 2,000,000.0

TileWidth: 256

TileHeight: 256

| TileMatrix id | Scale Denominator | Cell Size (m) | Matrix Width | Matrix Height |
|---------------|----------------------|-------------------|--------------|---------------|
| 0 | 62,779,017.857142866 | 17,578.1250000000 | 1 | 1 |
| 1 | 31,389,508.928571433 | 8789.0625000000 | 2 | 2 |
| 2 | 15,694,754.464285716 | 4394.5312500000 | 4 | 4 |
| 3 | 7,847,377.232142858 | 2197.2656250000 | 8 | 8 |
| 4 | 3,923,688.616071429 | 1098.6328125000 | 16 | 16 |
| 5 | 1,961,844.3080357146 | 549.3164062500 | 32 | 32 |
| 6 | 980,922.1540178573 | 274.6582031250 | 64 | 64 |
| 7 | 490,461.07700892864 | 137.3291015625 | 128 | 128 |
| 8 | 245,230.53850446432 | 68.6645507812 | 256 | 256 |
| 9 | 122,615.26925223216 | 34.3322753906 | 512 | 512 |
| 10 | 61,307.63462611608 | 17.1661376953 | 1024 | 1024 |
| 11 | 30,653.81731305804 | 8.5830688477 | 2048 | 2048 |
| 12 | 15,326.90865652902 | 4.2915344238 | 4096 | 4096 |

| | | | | |
|----|--------------------|--------------|--------|--------|
| 13 | 7663.45432826451 | 2.1457672119 | 8192 | 8192 |
| 14 | 3831.727164132255 | 1.0728836060 | 16,384 | 16,384 |
| 15 | 1915.8635820661275 | 0.5364418030 | 32,768 | 32,768 |

One can define an arbitrary number of zoom levels and does not need to include all the zoom levels defined here. Here, 16 zoom levels are illustrated.

NOTE: Please note that the EPSG:3035 is defined as: "Cartesian CS. Axes: northing, easting (Y,X). Orientations: north, east. UoM: m". Be aware the axis order is not (X,Y).

D.8. Canadian NAD83 Lambert Conformal Conic (CanadianNAD83_LCC)

URI: http://www.opengis.net/def/tilematrixset/OGC/1.0/CanadianNAD83_LCC

Table D.9 – Definition of the CanadianNAD83_LCC TileMatrixSet

CRS: <http://www.opengis.net/def/crs/EPSG/0/3978>, NAD83

BBOX LowerLeft: -7,786,476.885838887, -5,153,821.09213678

BBOX UpperRight: 7,148,753.233541353, 7,928,343.534071138

WellKnownScaleSet: N/A

PointOfOrigin: -34,655,800, 39,310,000

TileWidth: 256

TileHeight: 256

| TileMatrix id | Scale Denominator | Scale Denominator at latitudes 37. 897505 and 83.3032475 (informative) | Cartographic product (informative) | Cell Size (m) (true at the equator) | Matrix Width | Matrix Height |
|---------------|-------------------|---|---------------------------------------|--|--------------|---------------|
| 0 | 137,016,643. 1 | 145,000,000 | World | 38,364. 66006 | 5 | 5 |
| 1 | 80,320,101. 12 | 85,000,000 | World | 22,489. 62831 | 8 | 8 |
| 2 | 47,247,118.3 | 50,000,000 | Atlas SM | 13,229. 19313 | 13 | 14 |
| 3 | 28,348,270. 98 | 30,000,000 | Atlas SM | 7937. 515875 | 21 | 22 |

| | | | | | | |
|----|-------------------|------------|-----------|-----------------|---------|---------|
| 4 | 16,536,491. 41 | 17,500,000 | Atlas SM | 4630. 217594 | 36 | 38 |
| 5 | 9,449,423. 661 | 10,000,000 | Atlas MID | 2645. 838625 | 62 | 66 |
| 6 | 5,669,654. 196 | 6,000,000 | Atlas MID | 1587. 503175 | 103 | 110 |
| 7 | 3,307,298. 281 | 3,500,000 | Atlas MID | 926. 0435188 | 177 | 188 |
| 8 | 1,889,884. 732 | 2,000,000 | Atlas LG | 529.167725 | 309 | 329 |
| 9 | 1,133,930. 839 | 1,200,000 | Atlas LG | 317.500635 | 515 | 548 |
| 10 | 661,459. 6563 | 700,000 | Atlas LG | 185. 2087038 | 882 | 938 |
| 11 | 396,875. 7938 | 420,000 | NTDB 250K | 111. 1252223 | 1470 | 1563 |
| 12 | 236,235. 5915 | 250,000 | NTDB 250K | 66. 14596563 | 2469 | 2626 |
| 13 | 137,016. 6431 | 145,000 | NTDB 250K | 38. 36466006 | 4257 | 4528 |
| 14 | 80,320. 10112 | 85,000 | NTDB 50K | 22. 48962831 | 7262 | 7723 |
| 15 | 47,247.1183 | 50,000 | NTDB 50K | 13. 22919313 | 12,344 | 13,130 |
| 16 | 28,348. 27098 | 30,000 | NTDB 50K | 7. 937515875 | 20,574 | 21,882 |
| 17 | 16,536. 49141 | 17,500 | Geobase | 4. 630217594 | 35,269 | 37,512 |
| 18 | 9449.423661 | 10,000 | Geobase | 2. 645838625 | 61,720 | 65,646 |
| 19 | 5669.654196 | 6000 | Geobase | 1. 587503175 | 102,866 | 109,409 |
| 20 | 3307.298281 | 3500 | Geobase | 0. 926043519 | 176,341 | 187,558 |
| 21 | 1889.884732 | 2000 | Geobase | 0. 529167725 | 308,596 | 328,227 |
| 22 | 1133.930839 | 1200 | Geobase | 0. 317500635 | 514,327 | 547,044 |
| 23 | 661.4596563 | 700 | | 0. 185208704 | 881,703 | 937,790 |

| | | | |
|----|-----------------|-----------------|---------------------|
| 24 | 396.8757938 420 | 0. 111125222 | 1,469,505 1,562,983 |
| 25 | 236.2355915 250 | 0. 066145966 | 2,468,768 2,625,811 |

One can define an arbitrary number of zoom levels and does not need to include all the zoom levels defined here. Here, 26 zoom levels are illustrated.



E

ANNEX E (INFORMATIVE) VARIABLE WIDTH TILEMATRIXSET DEFINITIONS

ANNEX E (INFORMATIVE)

VARIABLE WIDTH TILEMATRIXSET DEFINITIONS

This annex includes definitions for TileMatrixSets utilizing the variable width capability. This capability allows for the coalescence of tiles in specific rows so that the overall width of the tile matrix is divided among fewer tiles. This is particularly well suited to define global grids in an Equirectangular Plate Carrée projection, where tiles closer to the pole cover a smaller physical area than tiles at the equator.

Such TileMatrixSets may therefore attempt to approximate equal area tiles. This makes them especially suitable for defining a global grid, which may form the basis for defining a Discrete Global Grid System (DGGS) as defined in [OGC Abstract Specification Topic 21 – Part 1](#), and Axis-Aligned DGGS per [OGC Abstract Specification Topic 21 – Part 4](#). Because the resulting tiles would likely only tend towards equal area but still be off by a significant margin, such a DGGS could not however conform to the *Equal-Area Earth DGGS* conformance class of [Topic 21 – Part 1](#), which specifies a maximum threshold of 1% difference.

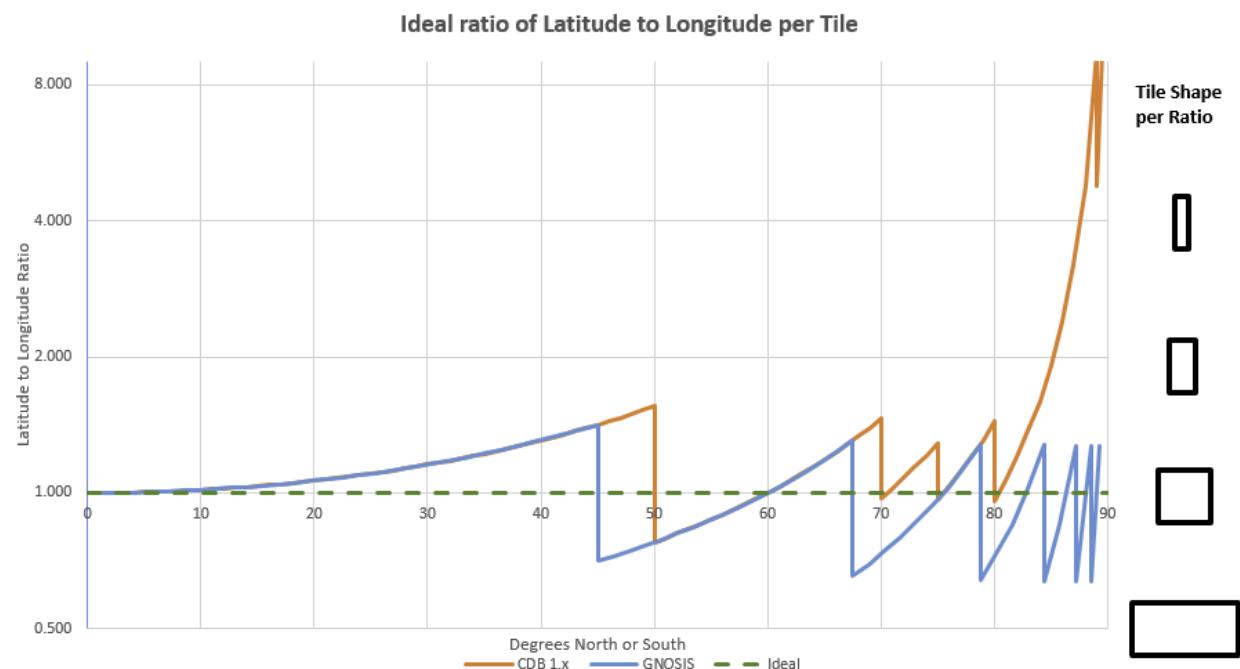


Figure E.1 — A comparison of variable width tile matrix sets against the ideal tile shape (source: CDB X sprint)

E.1. GNOSISGlobalGrid

URI: <http://www.opengis.net/def/tilematrixset/OGC/1.0/GNOSISGlobalGrid>

The **GNOSIS** Global Grid Tile Matrix Set defines tiles in the Equirectangular Plate Carrée projection (EPSG:4326 CRS) for the whole world while still attempting to approximate equal area tiles, even near the poles.

Starting at the tile matrix with identifier 1, a variable matrix coalescence factor is applied for polar tiles to tend towards equal area.

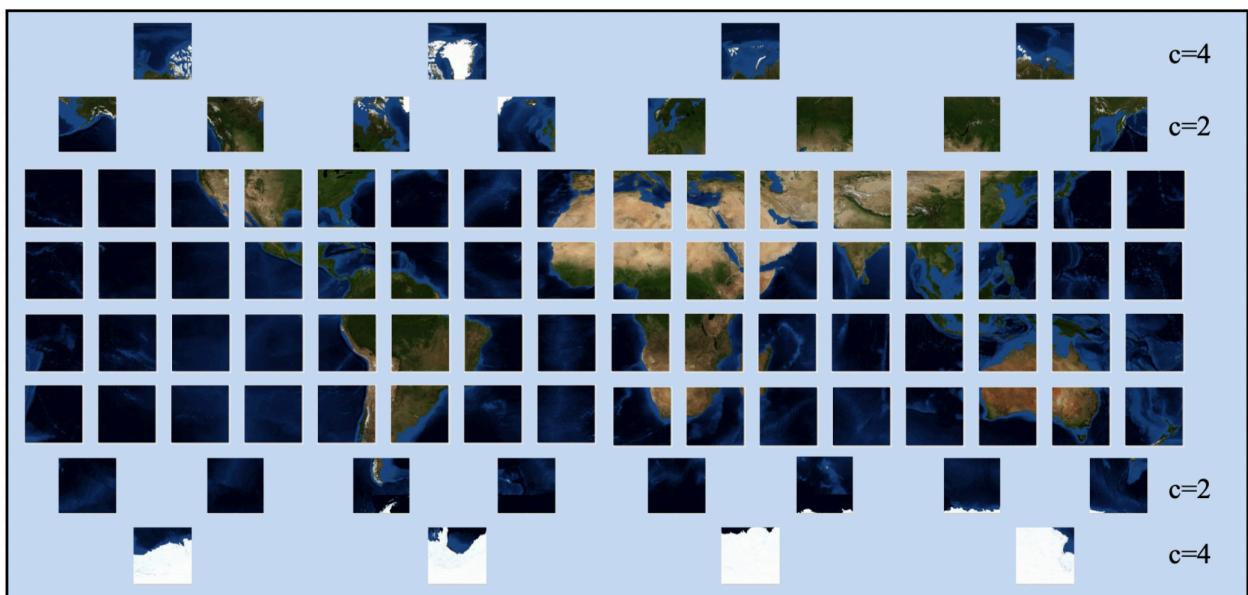


Figure E.2 – GNOSIS Global Grid (TileMatrix Id 2)

Table E.1 – Definition of the GNOSISGlobalGrid TileMatrixSet

CRS: <http://www.opengis.net/def/crs/EPSC/0/4326>, EPSG:4326

BBOX LowerLeft: -90, -180

BBOX UpperRight: 90, 180

WellKnownScaleSet: <http://www.opengis.net/def/wkss/OGC/1.0/GoogleCRS84Quad>

PointOfOrigin: 90, -180

TileWidth: 256

TileHeight: 256

| TileMatrix id | Scale Denominator | Cell Size (degrees) (true at the equator) | Matrix Width (c=1) | Matrix Height | Coalescing Coefficient © |
|---------------|-------------------------|---|--------------------|---------------|--------------------------|
| 0 | 139,770,566. 0071794 | 0.3515625 | 4 | 2 | |

| | | | | | |
|---|-------------------------|-------------------------------|-----|----|----------------|
| 1 | 69,885,283. 00358972 | 0.17578125 | 8 | 4 | Row 0: 2 |
| 2 | 34,942,641. 50179486 | 8.7890625×10^{-2} | 16 | 8 | Row 3: 2 |
| 3 | 17,471,320. 75089743 | $4.39453125 \times 10^{-2}$ | 32 | 16 | Row 0: 4 |
| 4 | 8,735,660. 375448715 | $2.197265625 \times 10^{-2}$ | 64 | 32 | Row 1: 2 |
| 5 | 4,367,830. 187724357 | $1.0986328125 \times 10^{-2}$ | 128 | 64 | Row 6: 2 |
| | | | | | Row 7: 4 |
| | | | | | Row 0: 8 |
| | | | | | Row 1: 4 |
| | | | | | Rows 2..3: 2 |
| | | | | | Rows 12..13: 2 |
| | | | | | Row 14: 4 |
| | | | | | Row 15: 8 |
| | | | | | Row 0: 16 |
| | | | | | Row 1: 8 |
| | | | | | Rows 2..3: 4 |
| | | | | | Rows 4..7: 2 |
| | | | | | Rows 24..27: 2 |
| | | | | | Rows 28..29: 4 |
| | | | | | Row 30: 8 |
| | | | | | Row 31: 16 |
| | | | | | Row 0: 32 |
| | | | | | Row 1: 16 |

Rows 2..3: **8**

Rows 4..7: **4**

Rows 8..15: **2**

Rows 48..55: **2**

Rows 56..59: **4**

Rows 60..61: **8**

Row 62: **16**

Row 63: **32**

One can define an arbitrary number of zoom levels and do not need to include all the ones defined here. Here, 6 zoom levels are illustrated. Levels 0 to 28 are officially defined, allowing to reach 2:1 scale while the matrix, row and column identifiers can still fit together within a single 64-bit key.

It is easy to implement procedurally: it is a quad-tree starting with eight 90 x 90 degree tiles at level 0, with the exception that tiles touching a pole are split into 3 tiles rather than 4 – the polar portion is not split longitude-wise. Therefore, there will always be only 4 tiles touching each pole.

NOTE 1: The GNOSIS Global Grid scales match the *GoogleCRS84Quad* Well Known Scale Set, but starts at the third scale of the set.

NOTE 2: Aside from the variable width considerations, the only other difference with the *WorldCRS84Quad TileMatrixSet* is the fact that the latter starts at the second scale of the WKSS – its TileMatrix identifier 1 is equivalent to the *GNOSISGlobalGrid* TileMatrix identifier 0.



Figure E.3 – GNOSIS Global Grid (TileMatrices Id 0-3)

E.2. CDB 1 GlobalGrid

URI: <http://www.opengis.net/def/tilematrixset/OGC/1.0/CDB1GlobalGrid>

This CDB 1 Global Grid Tile Matrix Set defines tiles in the Equirectangular Plate Carrée projection (EPSG:4326 CRS) for the whole world, based on the level of details and zones defined by the [OGC CDB 1.x](#) specifications, which can be encoded following this standard with the use of variable widths.

Table E.2 – Definition of the CDB1GlobalGrid TileMatrixSet

CRS: <http://www.opengis.net/def/crs/EPSC/0/4326>, EPSG:4326

BBOX LowerLeft: -90, -180

BBOX UpperRight: 90, 180

PointOfOrigin: 90, -180

TileWidth & TileHeight: 1024 (for tile matrices id 0 and up)

| TileMatrix id | Scale Denominator | Cell Size (degrees) (true at the equator) | Tile Width & Height | Matrix Width (c=1) | Matrix Height | Coalescing Coefficient © |
|------------------|----------------------|---|---------------------------|--------------------------|------------------|-----------------------------|
| -1 | 776,503.144 | 0.001953125 | 512 | 360 | 180 | Row 0: 12 |
| 0 | 388,251.572 | 0.009765625 | 1024 | 360 | 180 | Rows 1..9: 6 |
| | | | | | | Rows 10..14: 4 |
| | | | | | | Rows 15..19: 3 |
| | | | | | | Rows 20..39: 2 |
| | | | | | | Rows 140.. 159: 2 |
| | | | | | | Rows 160.. 164: 3 |
| | | | | | | Rows 165.. 169: 4 |
| | | | | | | Rows 170.. 178: 6 |
| | | | | | | Row 179: 12 |
| | | | | | | Row 0: 12 |
| | | | | | | Rows 1..9: 6 |

| | | | | | | | |
|---|-------------|-------------|------|-----|-----|--|----------------------|
| | | | | | | | Rows 10..14: 4 |
| | | | | | | | Rows 15..19: 3 |
| | | | | | | | Rows 20..39: 2 |
| | | | | | | | Rows 140.. 159: 2 |
| | | | | | | | Rows 160.. 164: 3 |
| | | | | | | | Rows 165.. 169: 4 |
| | | | | | | | Rows 170.. 178: 6 |
| | | | | | | | Row 179: 12 |
| | | | | | | | Row 0..1: 12 |
| | | | | | | | Rows 2..19: 6 |
| | | | | | | | Rows 20..29: 4 |
| | | | | | | | Rows 30..39: 3 |
| | | | | | | | Rows 40..79: 2 |
| 1 | 194,125.786 | 0.004882813 | 1024 | 720 | 360 | | Rows 280.. 319: 2 |
| | | | | | | | Rows 320.. 329: 3 |
| | | | | | | | Rows 330.. 339: 4 |
| | | | | | | | Rows 340.. 357: 6 |
| | | | | | | | Row 358..359: 12 |

For the tile matrices with negative identifiers of the CDB 1 Global Grid, the tiles' geographic extents remain the same as those of tile matrix 0, but the tile size in cells is reduced. The levels -1 to 1 are shown here. For the CDB 1 Global Grid, the polar adjustment zones corresponding to coalescence factors are the same (at a given latitude) for all tile matrices of the set.



Figure E.4 – CDB Zones (from OGC CDB Volume 1)

One can define an arbitrary number of zoom levels and do not need to include all the ones defined here. Here, 3 zoom levels are illustrated.



Figure E.5 – CDB Level of Details (from OGC CDB Volume 1)



F

ANNEX F (INFORMATIVE) EXAMPLE ENCODINGS FOR COMMON TILERATRIXSETS

ANNEX F (INFORMATIVE)

EXAMPLE ENCODINGS FOR COMMON TILEMATRIXSETS

This Annex provides examples of JSON and XML encodings than can be used to define tile matrix sets.

F.1. JSON schema for TileMatrixSet

The TileMatrixSet data structure has been transformed into JSON schemas as described in section Clause 7 and provided with this standard as indicated in Annex B. JSON document instances describing TileMatrixSets (including the ones reproduced in this annex) should validate against these schemas. The following JSON Schema fragment reproduces the main module of the TileMatrixSet schema.

```
{  
  "$schema": "https://json-schema.org/draft/2019-09/schema",  
  "title": "Tile Matrix Set Definition",  
  "description": "A definition of a tile matrix set following the Tile Matrix Set standard. For tileset metadata, such a description (in `tileMatrixSet` property) is only required for offline use, as an alternative to a link with a `http://www.opengis.net/def/rel/ogc/1.0/tiling-scheme` relation type.",  
  "type": "object",  
  "required": ["crs", "tileMatrices"],  
  "properties": {  
    "title": {  
      "description": "Title of this tile matrix set, normally used for display to a human",  
      "type": "string"  
    },  
    "description": {  
      "description": "Brief narrative description of this tile matrix set, normally available for display to a human",  
      "type": "string"  
    },  
    "keywords": {  
      "description": "Unordered list of one or more commonly used or formalized word(s) or phrase(s) used to describe this tile matrix set",  
      "type": "array",  
      "items": {  
        "type": "string"  
      }  
    },  
    "id": {  
      "type": "string"  
    }  
  }  
}
```

```

    "description": "Tile matrix set identifier. Implementation of 'identifier'",
    "type": "string"
},
"uri": {
    "description": "Reference to an official source for this tileMatrixSet",
    "type": "string",
    "format": "uri"
},
"orderedAxes": {
    "type": "array",
    "minItems": 1,
    "items": {
        "type": "string"
    }
},
"crs": { "allOf": [
    { "description": "Coordinate Reference System (CRS)" },
    { "$ref": "crs.json" }
] },
"wellKnownScaleSet": {
    "description": "Reference to a well-known scale set",
    "type": "string",
    "format": "uri"
},
"boundingBox": {
    "allOf": [
        { "description": "Minimum bounding rectangle surrounding the tile matrix
set, in the supported CRS" },
        { "$ref": "2DBoundingBox.json" }
    ],
    "tileMatrices": {
        "type": "array",
        "description": "Describes scale levels and its tile matrices",
        "items": {
            {
                "$ref": "tileMatrix.json"
            }
        }
    }
}
}

```

F.2. XML schema for TileMatrixSet

The TileMatrixSet data structure has been transformed into XSD schemas as described in section Clause 7 and provided with this standard as indicated in Annex B. XML document instances describing TileMatrixSets (including the ones reproduced in this annex) should validate against these schemas. The following XML Schema fragment reproduces the main module of the TileMatrixSet schema.

```

<?xml version="1.0" encoding="UTF-8"?>
<!-- Edited with XMLSpy v2008 sp1 (http://www.altova.com) by Joan Masó
(UAB-CREAF-MiraMon). Based on previous documents of Keith Pomakis. -->
<schema xmlns="http://www.w3.org/2001/XMLSchema" xmlns:tms="http://www.opengis.net/tms/2.0" xmlns:tmSc="http://www.opengis.net/tms/2.0/common"
targetNamespace="http://www.opengis.net/tms/2.0" elementFormDefault="qualified"
xml:lang="en">

```

```

<annotation>
  <appinfo>TileMatrixSet 2021-02-02</appinfo>
  <documentation>
    This XML Schema Document encodes the TileMatrixSet data structures.
    TMS is an OGC Standard Copyright (c) 2021 Open Geospatial Consortium, Inc.
    All Rights Reserved.
    To obtain additional rights of use, visit http://www.opengeospatial.org/legal.
  </documentation>
</annotation>


  <annotation>
    <documentation>Describes a particular set of tile matrices.</documentation>
  </annotation>
  <complexType>
    <complexContent>
      <extension base="tmsc:DescriptionType">
        <sequence>
          <element ref="tmsc:Identifier" minOccurs="0">
            <annotation>
              <documentation>Tile matrix set identifier</documentation>
            </annotation>
          </element>
          <element name="uri" type="anyURI" minOccurs="0">
            <annotation>
              <documentation>Reference to an official source for this
tileMatrixSet</documentation>
            </annotation>
          </element>
          <element ref="tmsc:BoundingBox" minOccurs="0">
            <annotation>
              <documentation>
                Minimum bounding rectangle surrounding
                the visible layer presented by this tile matrix
                set, in the supported CRS </documentation>
              </annotation>
            </element>
            <element ref="tmsc:CRS">
              <annotation>
                <documentation>Reference to one coordinate reference
                system (CRS).</documentation>
              </annotation>
            </element>
            <element name="OrderedAxes" type="string" minOccurs="0">
              <annotation>
                <documentation>
                  Names of dimensions in this CRS, separated by a comma.
                  These names are specified by the CRS definition,
                  but can also be specified here to avoid any
ambiguity.
                </documentation>
              </annotation>
            </element>
          </sequence>
        </extension>
      </complexContent>
    </complexType>
  </element>

```

```

        </annotation>
    </element>
<element name="WellKnownScaleSet" type="anyURI" minOccurs="0">
    <annotation>
        <documentation>Reference to a well known scale set.
            http://www.opengis.net/def/wkss/OGC/1.0/GlobalCRS84Scale,
            http://www.opengis.net/def/wkss/OGC/1.0/GlobalCRS84Pixel,
            http://www.opengis.net/def/wkss/OGC/1.0/GoogleCRS84Quad,
            http://www.opengis.net/def/wkss/OGC/1.0/GoogleMapsCompatible and
            http://www.opengis.net/def/wkss/OGC/1.0/WorldMercatorWGS84 are
            possible values that are defined in Annex C. It has to be consistent
with the
            crs and with the ScaleDenominators of the TileMatrix elements.
        </documentation>
    </annotation>
</element>
<element ref="tms:TileMatrix" maxOccurs="unbounded">
    <annotation>
        <documentation>Describes a scale level and its tile matrix.
    </documentation>
    </annotation>
</element>
<any namespace="#other" processContents="lax" minOccurs="0" maxOccurs=
"unbounded">
    <annotation>
        <documentation>This is an extension point for other properties in the
        TileMatrixSet.</documentation>
    </annotation>
</any>
</sequence>
<attribute name="id" type="string">
    <annotation>
        <documentation/>
    </annotation>
</attribute>
</extension>
</complexContent>
</complexType>
</element>
<!-- **** The TileMatrix element.
-->
<!-- **** -->
<!-- **** -->
<element name="TileMatrix">
    <annotation>
        <documentation>Describes a particular tile matrix.</documentation>
    </annotation>
    <complexType>
        <complexContent>
            <extension base="tmsc:DescriptionType">
                <sequence>
                    <element ref="tmsc:Identifier">
                        <annotation>
                            <documentation>Tile matrix identifier. Typically an abbreviation of
                                the ScaleDenominator value or its equivalent pixel size</documentation>
                        </annotation>
                    </element>
                    <element name="ScaleDenominator" type="double">
                        <annotation>
                            <documentation>Scale denominator of this tile matrix</documentation>
                        </annotation>
                    </element>
                    <element name="CellSize" type="double">

```

```

<annotation>
  <documentation>Cell size of this tile matrix</documentation>
</annotation>
</element>
<element name="CornerOfOrigin" minOccurs="0">
  <annotation>
    <documentation>
      The corner of the tile matrix (_topLeft_ or _bottomLeft_) used as the
      origin for numbering tile rows and columns. This corner is also a corner of
      the (0, 0) tile.
    </documentation>
  </annotation>
  <simpleType>
    <restriction base="string">
      <enumeration value="topLeft"/>
      <enumeration value="bottomLeft"/>
    </restriction>
  </simpleType>
</element>
<element name="PointOfOrigin" type="tmsc:PositionType">
  <annotation>
    <documentation>
      Precise position in CRS coordinates of the corner of origin (e.g. the
      top-left corner) for this tile matrix.
      This position is also a corner of the (0, 0) tile.
      In previous version, this was 'topLeftCorner' and 'cornerOfOrigin'
      did not exist.
    </documentation>
  </annotation>
</element>
<element name="TileWidth" type="positiveInteger">
  <annotation>
    <documentation>Width of each tile of this tile matrix in pixels.
  </documentation>
  </annotation>
</element>
<element name="TileHeight" type="positiveInteger">
  <annotation>
    <documentation>Height of each tile of this tile matrix in
    pixels</documentation>
  </annotation>
</element>
<element name="MatrixWidth" type="positiveInteger">
  <annotation>
    <documentation>Width of the matrix (number of tiles in
    width)</documentation>
  </annotation>
</element>
<element name="MatrixHeight" type="positiveInteger">
  <annotation>
    <documentation>Height of the matrix (number of tiles in
    height)</documentation>
  </annotation>
</element>
<element name="VariableMatrixWidth" minOccurs="0" maxOccurs="unbounded">
  <annotation>
    <documentation>The rows mention in this array apply the coalesce
    mechanisms to fuse n contiguous tiles in the width axis into a single
    tile</documentation>
  </annotation>
  <complexType>
    <sequence>
      <element name="Coalesce" type="positiveInteger">

```

```

<annotation>
  <documentation>Number of tiles in width that coalesce in a single
tile for these rows</documentation>
</annotation>
</element>
<element name="MinTileRow" type="nonNegativeInteger">
  <annotation>
    <documentation>First tile row where the coalescence factor applies
for this tilematrix</documentation>
  </annotation>
</element>
<element name="MaxTileRow" type="nonNegativeInteger">
  <annotation>
    <documentation>Last tile row where the coalescence factor applies
for this tilematrix</documentation>
  </annotation>
</element>
</sequence>
</complexType>
</element>
<any namespace="#other" processContents="lax" minOccurs="0" maxOccurs=
"unbounded">
  <annotation>
    <documentation>This is an extension point for other properties in the
TileMatrix.</documentation>
  </annotation>
</any>
</sequence>
</extension>
</complexContent>
</complexType>
</element>
</schema>

```

F.3. Web Mercator Quad

These are the JSON and XML definitions of the WebMercatorQuad tile matrix set (see Annex D.1) that can be reproduced by other standards needing to define a tile matrix set. Not all TileMatrix elements need to be included and including other TileMatrices for more detailed scales is possible if they follow the same pattern.

One can define an arbitrary number of zoom levels. Here, 25 zoom levels are illustrated.

F.3.1. Web Mercator Quad (JSON encoding)

```
{
  "id": "WebMercatorQuad",
  "title": "Google Maps Compatible for the World",
  "uri": "http://www.opengis.net/def/tilematrixset/OGC/1.0/WebMercatorQuad",
  "crs": "http://www.opengis.net/def/crs/EPSG/0/3857",
  "orderedAxes": ["X", "Y"],
  "wellKnownScaleSet": "http://www.opengis.net/def/wkss/OGC/1.0/
GoogleMapsCompatible",
  "tileMatrices": [
    [
      {
        "level": 0,
        "x": 0,
        "y": 0
      }
    ],
    [
      {
        "level": 1,
        "x": 0,
        "y": 0
      }
    ],
    [
      {
        "level": 2,
        "x": 0,
        "y": 0
      }
    ],
    [
      {
        "level": 3,
        "x": 0,
        "y": 0
      }
    ],
    [
      {
        "level": 4,
        "x": 0,
        "y": 0
      }
    ],
    [
      {
        "level": 5,
        "x": 0,
        "y": 0
      }
    ],
    [
      {
        "level": 6,
        "x": 0,
        "y": 0
      }
    ],
    [
      {
        "level": 7,
        "x": 0,
        "y": 0
      }
    ],
    [
      {
        "level": 8,
        "x": 0,
        "y": 0
      }
    ],
    [
      {
        "level": 9,
        "x": 0,
        "y": 0
      }
    ],
    [
      {
        "level": 10,
        "x": 0,
        "y": 0
      }
    ],
    [
      {
        "level": 11,
        "x": 0,
        "y": 0
      }
    ],
    [
      {
        "level": 12,
        "x": 0,
        "y": 0
      }
    ],
    [
      {
        "level": 13,
        "x": 0,
        "y": 0
      }
    ],
    [
      {
        "level": 14,
        "x": 0,
        "y": 0
      }
    ],
    [
      {
        "level": 15,
        "x": 0,
        "y": 0
      }
    ],
    [
      {
        "level": 16,
        "x": 0,
        "y": 0
      }
    ],
    [
      {
        "level": 17,
        "x": 0,
        "y": 0
      }
    ],
    [
      {
        "level": 18,
        "x": 0,
        "y": 0
      }
    ],
    [
      {
        "level": 19,
        "x": 0,
        "y": 0
      }
    ],
    [
      {
        "level": 20,
        "x": 0,
        "y": 0
      }
    ],
    [
      {
        "level": 21,
        "x": 0,
        "y": 0
      }
    ],
    [
      {
        "level": 22,
        "x": 0,
        "y": 0
      }
    ],
    [
      {
        "level": 23,
        "x": 0,
        "y": 0
      }
    ],
    [
      {
        "level": 24,
        "x": 0,
        "y": 0
      }
    ]
  ]
}
```

```
{
  "id": "0",
  "scaleDenominator": 559082264.028717,
  "cellSize": 156543.033928041,
  "pointOfOrigin": [-20037508.3427892,20037508.3427892],
  "tileWidth": 256,
  "tileHeight": 256,
  "matrixWidth": 1,
  "matrixHeight": 1
},
{
  "id": "1",
  "scaleDenominator": 279541132.014358,
  "cellSize": 78271.5169640204,
  "pointOfOrigin": [-20037508.3427892,20037508.3427892],
  "tileWidth": 256,
  "tileHeight": 256,
  "matrixWidth": 2,
  "matrixHeight": 2
},
{
  "id": "2",
  "scaleDenominator": 139770566.007179,
  "cellSize": 39135.7584820102,
  "pointOfOrigin": [-20037508.3427892,20037508.3427892],
  "tileWidth": 256,
  "tileHeight": 256,
  "matrixWidth": 4,
  "matrixHeight": 4
},
{
  "id": "3",
  "scaleDenominator": 69885283.0035897,
  "cellSize": 19567.8792410051,
  "pointOfOrigin": [-20037508.3427892,20037508.3427892],
  "tileWidth": 256,
  "tileHeight": 256,
  "matrixWidth": 8,
  "matrixHeight": 8
},
{
  "id": "4",
  "scaleDenominator": 34942641.5017948,
  "cellSize": 9783.93962050256,
  "pointOfOrigin": [-20037508.3427892,20037508.3427892],
  "tileWidth": 256,
  "tileHeight": 256,
  "matrixWidth": 16,
  "matrixHeight": 16
},
{
  "id": "5",
  "scaleDenominator": 17471320.7508974,
  "cellSize": 4891.96981025128,
  "pointOfOrigin": [-20037508.3427892,20037508.3427892],
  "tileWidth": 256,
  "tileHeight": 256,
  "matrixWidth": 32,
  "matrixHeight": 32
},
{
  "id": "6",
  "scaleDenominator": 8735660.37544871,
```

```

    "cellSize": 2445.98490512564,
    "pointOfOrigin": [-20037508.3427892,20037508.3427892],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 64,
    "matrixHeight": 64
  },
  {
    "id": "7",
    "scaleDenominator": 4367830.18772435,
    "cellSize": 1222.99245256282,
    "pointOfOrigin": [-20037508.3427892,20037508.3427892],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 128,
    "matrixHeight": 128
  },
  {
    "id": "8",
    "scaleDenominator": 2183915.09386217,
    "cellSize": 611.49622628141,
    "pointOfOrigin": [-20037508.3427892,20037508.3427892],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 256,
    "matrixHeight": 256
  },
  {
    "id": "9",
    "scaleDenominator": 1091957.54693108,
    "cellSize": 305.748113140704,
    "pointOfOrigin": [-20037508.3427892,20037508.3427892],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 512,
    "matrixHeight": 512
  },
  {
    "id": "10",
    "scaleDenominator": 545978.773465544,
    "cellSize": 152.874056570352,
    "pointOfOrigin": [-20037508.3427892,20037508.3427892],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 1024,
    "matrixHeight": 1024
  },
  {
    "id": "11",
    "scaleDenominator": 272989.386732772,
    "cellSize": 76.4370282851762,
    "pointOfOrigin": [-20037508.3427892,20037508.3427892],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 2048,
    "matrixHeight": 2048
  },
  {
    "id": "12",
    "scaleDenominator": 136494.693366386,
    "cellSize": 38.2185141425881,
    "pointOfOrigin": [-20037508.3427892,20037508.3427892],
    "tileWidth": 256,

```

```
        "tileHeight": 256,
        "matrixWidth": 4096,
        "matrixHeight": 4096
    },
    {
        "id": "13",
        "scaleDenominator": 68247.346683193,
        "cellSize": 19.109257071294,
        "pointOfOrigin": [-20037508.3427892,20037508.3427892],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 8192,
        "matrixHeight": 8192
    },
    {
        "id": "14",
        "scaleDenominator": 34123.6733415964,
        "cellSize": 9.55462853564703,
        "pointOfOrigin": [-20037508.3427892,20037508.3427892],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 16384,
        "matrixHeight": 16384
    },
    {
        "id": "15",
        "scaleDenominator": 17061.8366707982,
        "cellSize": 4.77731426782351,
        "pointOfOrigin": [-20037508.3427892,20037508.3427892],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 32768,
        "matrixHeight": 32768
    },
    {
        "id": "16",
        "scaleDenominator": 8530.91833539913,
        "cellSize": 2.38865713391175,
        "pointOfOrigin": [-20037508.3427892,20037508.3427892],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 65536,
        "matrixHeight": 65536
    },
    {
        "id": "17",
        "scaleDenominator": 4265.45916769956,
        "cellSize": 1.19432856695587,
        "pointOfOrigin": [-20037508.3427892,20037508.3427892],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 131072,
        "matrixHeight": 131072
    },
    {
        "id": "18",
        "scaleDenominator": 2132.72958384978,
        "cellSize": 0.597164283477939,
        "pointOfOrigin": [-20037508.3427892,20037508.3427892],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 262144,
        "matrixHeight": 262144
    }
]
```

```

},
{
  "id": "19",
  "scaleDenominator": 1066.36479192489,
  "cellSize": 0.29858214173897,
  "pointOfOrigin": [-20037508.3427892,20037508.3427892],
  "tileWidth": 256,
  "tileHeight": 256,
  "matrixWidth": 524288,
  "matrixHeight": 524288
},
{
  "id": "20",
  "scaleDenominator": 533.182395962445,
  "cellSize": 0.149291070869485,
  "pointOfOrigin": [-20037508.3427892,20037508.3427892],
  "tileWidth": 256,
  "tileHeight": 256,
  "matrixWidth": 1048576,
  "matrixHeight": 1048576
},
{
  "id": "21",
  "scaleDenominator": 266.591197981222,
  "cellSize": 0.0746455354347424,
  "pointOfOrigin": [-20037508.3427892,20037508.3427892],
  "tileWidth": 256,
  "tileHeight": 256,
  "matrixWidth": 2097152,
  "matrixHeight": 2097152
},
{
  "id": "22",
  "scaleDenominator": 133.295598990611,
  "cellSize": 0.0373227677173712,
  "pointOfOrigin": [-20037508.3427892,20037508.3427892],
  "tileWidth": 256,
  "tileHeight": 256,
  "matrixWidth": 4194304,
  "matrixHeight": 4194304
},
{
  "id": "23",
  "scaleDenominator": 66.6477994953056,
  "cellSize": 0.0186613838586856,
  "pointOfOrigin": [-20037508.3427892,20037508.3427892],
  "tileWidth": 256,
  "tileHeight": 256,
  "matrixWidth": 8388608,
  "matrixHeight": 8388608
},
{
  "id": "24",
  "scaleDenominator": 33.3238997476528,
  "cellSize": 0.0093306919293428,
  "pointOfOrigin": [-20037508.3427892,20037508.3427892],
  "tileWidth": 256,
  "tileHeight": 256,
  "matrixWidth": 16777216,
  "matrixHeight": 16777216
}
]

```

}

F.3.2. Web Mercator Quad (XML encoding)

```
<?xml version="1.0" encoding="UTF-8"?>
<TileMatrixSet id="WebMercatorQuad" xmlns="http://www.opengis.net/tms/2.0"
  xmlns:tmSc="http://www.opengis.net/tms/2.0/common" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="http://www.opengis.net/tms/2.0 ../tilematrixset.xsd">
  <tmSc:Title>Google Maps Compatible for the World</tmSc:Title>
  <tmSc:Identifier>WebMercatorQuad</tmSc:Identifier>
  <uri>http://www.opengis.net/def/tilematrixset/OGC/1.0/WebMercatorQuad</uri>
  <tmSc:CRS>
    <tmSc:URI>http://www.opengis.net/def/crs/EPSG/0/3857</tmSc:URI>
  </tmSc:CRS>
  <OrderedAxes>E,N</OrderedAxes>
  <WellKnownScaleSet>http://www.opengis.net/def/wkss/OGC/1.0/GoogleMapsCompatible</WellKnownScaleSet>
  <TileMatrix>
    <tmSc:Identifier>0</tmSc:Identifier>
    <ScaleDenominator>559082264.028717</ScaleDenominator>
    <CellSize>559082264.028717</CellSize>
    <PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
    <TileWidth>256</TileWidth>
    <TileHeight>256</TileHeight>
    <MatrixWidth>1</MatrixWidth>
    <MatrixHeight>1</MatrixHeight>
  </TileMatrix>
  <TileMatrix>
    <tmSc:Identifier>1</tmSc:Identifier>
    <ScaleDenominator>279541132.014358</ScaleDenominator>
    <CellSize>279541132.014358</CellSize>
    <PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
    <TileWidth>256</TileWidth>
    <TileHeight>256</TileHeight>
    <MatrixWidth>2</MatrixWidth>
    <MatrixHeight>2</MatrixHeight>
  </TileMatrix>
  <TileMatrix>
    <tmSc:Identifier>2</tmSc:Identifier>
    <ScaleDenominator>139770566.007179</ScaleDenominator>
    <CellSize>139770566.007179</CellSize>
    <PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
    <TileWidth>256</TileWidth>
    <TileHeight>256</TileHeight>
    <MatrixWidth>4</MatrixWidth>
    <MatrixHeight>4</MatrixHeight>
  </TileMatrix>
  <TileMatrix>
    <tmSc:Identifier>3</tmSc:Identifier>
    <ScaleDenominator>69885283.0035897</ScaleDenominator>
    <CellSize>69885283.0035897</CellSize>
    <PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
    <TileWidth>256</TileWidth>
    <TileHeight>256</TileHeight>
    <MatrixWidth>8</MatrixWidth>
    <MatrixHeight>8</MatrixHeight>
  </TileMatrix>
  <TileMatrix>
    <tmSc:Identifier>4</tmSc:Identifier>
    <ScaleDenominator>34942641.5017948</ScaleDenominator>
```

```

<CellSize>34942641.5017948</CellSize>
<PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>16</MatrixWidth>
<MatrixHeight>16</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>5</tmsc:Identifier>
  <ScaleDenominator>17471320.7508974</ScaleDenominator>
  <CellSize>17471320.7508974</CellSize>
  <PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>32</MatrixWidth>
  <MatrixHeight>32</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>6</tmsc:Identifier>
  <ScaleDenominator>8735660.37544871</ScaleDenominator>
  <CellSize>8735660.37544871</CellSize>
  <PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>64</MatrixWidth>
  <MatrixHeight>64</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>7</tmsc:Identifier>
  <ScaleDenominator>4367830.18772435</ScaleDenominator>
  <CellSize>4367830.18772435</CellSize>
  <PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>128</MatrixWidth>
  <MatrixHeight>128</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>8</tmsc:Identifier>
  <ScaleDenominator>2183915.09386217</ScaleDenominator>
  <CellSize>2183915.09386217</CellSize>
  <PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>256</MatrixWidth>
  <MatrixHeight>256</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>9</tmsc:Identifier>
  <ScaleDenominator>1091957.54693108</ScaleDenominator>
  <CellSize>1091957.54693108</CellSize>
  <PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>512</MatrixWidth>
  <MatrixHeight>512</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>10</tmsc:Identifier>
  <ScaleDenominator>545978.773465544</ScaleDenominator>
  <CellSize>545978.773465544</CellSize>
  <PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
  <TileWidth>256</TileWidth>

```

```

<TileHeight>256</TileHeight>
<MatrixWidth>1024</MatrixWidth>
<MatrixHeight>1024</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>11</tmsc:Identifier>
<ScaleDenominator>272989.386732772</ScaleDenominator>
<CellSize>272989.386732772</CellSize>
<PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>2048</MatrixWidth>
<MatrixHeight>2048</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>12</tmsc:Identifier>
<ScaleDenominator>136494.693366386</ScaleDenominator>
<CellSize>136494.693366386</CellSize>
<PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>4096</MatrixWidth>
<MatrixHeight>4096</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>13</tmsc:Identifier>
<ScaleDenominator>68247.346683193</ScaleDenominator>
<CellSize>68247.346683193</CellSize>
<PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>8192</MatrixWidth>
<MatrixHeight>8192</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>14</tmsc:Identifier>
<ScaleDenominator>34123.6733415964</ScaleDenominator>
<CellSize>34123.6733415964</CellSize>
<PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>16384</MatrixWidth>
<MatrixHeight>16384</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>15</tmsc:Identifier>
<ScaleDenominator>17061.8366707982</ScaleDenominator>
<CellSize>17061.8366707982</CellSize>
<PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>32768</MatrixWidth>
<MatrixHeight>32768</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>16</tmsc:Identifier>
<ScaleDenominator>8530.91833539913</ScaleDenominator>
<CellSize>8530.91833539913</CellSize>
<PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>65536</MatrixWidth>
<MatrixHeight>65536</MatrixHeight>

```

```

</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>17</tmsc:Identifier>
  <ScaleDenominator>4265.45916769956</ScaleDenominator>
  <CellSize>4265.45916769956</CellSize>
  <PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>131072</MatrixWidth>
  <MatrixHeight>131072</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>18</tmsc:Identifier>
  <ScaleDenominator>2132.72958384978</ScaleDenominator>
  <CellSize>2132.72958384978</CellSize>
  <PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>262144</MatrixWidth>
  <MatrixHeight>262144</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>19</tmsc:Identifier>
  <ScaleDenominator>1066.36479192489</ScaleDenominator>
  <CellSize>1066.36479192489</CellSize>
  <PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>524288</MatrixWidth>
  <MatrixHeight>524288</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>20</tmsc:Identifier>
  <ScaleDenominator>533.182395962445</ScaleDenominator>
  <CellSize>533.182395962445</CellSize>
  <PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>1048576</MatrixWidth>
  <MatrixHeight>1048576</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>21</tmsc:Identifier>
  <ScaleDenominator>266.591197981222</ScaleDenominator>
  <CellSize>266.591197981222</CellSize>
  <PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>2097152</MatrixWidth>
  <MatrixHeight>2097152</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>22</tmsc:Identifier>
  <ScaleDenominator>133.295598990611</ScaleDenominator>
  <CellSize>133.295598990611</CellSize>
  <PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>4194304</MatrixWidth>
  <MatrixHeight>4194304</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>23</tmsc:Identifier>

```

```

<ScaleDenominator>66.6477994953056</ScaleDenominator>
<CellSize>66.6477994953056</CellSize>
<PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>8388608</MatrixWidth>
<MatrixHeight>8388608</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>24</tmsc:Identifier>
  <ScaleDenominator>33.3238997476528</ScaleDenominator>
  <CellSize>33.3238997476528</CellSize>
  <PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>16777216</MatrixWidth>
  <MatrixHeight>16777216</MatrixHeight>
</TileMatrix>
</TileMatrixSet>

```

F.4. World CRS84 Quad

Variant 1: World CRS84 Quad (recommended)

These are the JSON and XML definitions of the WorldCRS84Quad tile matrix set (see Annex D.2.1) that can be reproduced by other standards needing to define a tile matrix set. Not all TileMatrix elements need to be included and including other TileMatrices for more detailed scales is possible if they follow the same pattern.

One can define an arbitrary number of zoom levels. Here, 23 zoom levels are illustrated.

F.4.1. World CRS84 Quad (recommended, JSON encoding)

```
{
  "id": "WorldCRS84Quad",
  "title": "CRS84 for the World",
  "uri": "http://www.opengis.net/def/tilematrixset/OGC/1.0/WorldCRS84Quad",
  "crs": "http://www.opengis.net/def/crs/OGC/1.3/CRS84",
  "orderedAxes": [ "Lon", "Lat" ],
  "wellKnownScaleSet": "http://www.opengis.net/def/wkss/OGC/1.0/
GoogleCRS84Quad",
  "tileMatrices": [
    {
      "id": "0",
      "scaleDenominator": 279541132.014358,
      "cellSize": 0.703125,
      "pointOfOrigin": [ -180, 90 ],
      "tileWidth": 256,
      "tileHeight": 256,
      "matrixWidth": 2,
      "matrixHeight": 1
    },
    {
      "id": "1",
      "scaleDenominator": 139770660.007179,
      "cellSize": 0.3515625,
      "pointOfOrigin": [ -180, 45 ],
      "tileWidth": 128,
      "tileHeight": 128,
      "matrixWidth": 1,
      "matrixHeight": 1
    },
    {
      "id": "2",
      "scaleDenominator": 69885330.0035895,
      "cellSize": 0.17578125,
      "pointOfOrigin": [ -180, 0 ],
      "tileWidth": 64,
      "tileHeight": 64,
      "matrixWidth": 1,
      "matrixHeight": 1
    },
    {
      "id": "3",
      "scaleDenominator": 34942665.00179475,
      "cellSize": 0.087890625,
      "pointOfOrigin": [ -180, -45 ],
      "tileWidth": 32,
      "tileHeight": 32,
      "matrixWidth": 1,
      "matrixHeight": 1
    },
    {
      "id": "4",
      "scaleDenominator": 17471332.500897375,
      "cellSize": 0.0439453125,
      "pointOfOrigin": [ -180, -90 ],
      "tileWidth": 16,
      "tileHeight": 16,
      "matrixWidth": 1,
      "matrixHeight": 1
    },
    {
      "id": "5",
      "scaleDenominator": 8735666.2504486875,
      "cellSize": 0.02197265625,
      "pointOfOrigin": [ -180, -135 ],
      "tileWidth": 8,
      "tileHeight": 8,
      "matrixWidth": 1,
      "matrixHeight": 1
    },
    {
      "id": "6",
      "scaleDenominator": 4367833.12522434375,
      "cellSize": 0.010986328125,
      "pointOfOrigin": [ -180, -180 ],
      "tileWidth": 4,
      "tileHeight": 4,
      "matrixWidth": 1,
      "matrixHeight": 1
    },
    {
      "id": "7",
      "scaleDenominator": 2183916.562612171875,
      "cellSize": 0.0054931640625,
      "pointOfOrigin": [ -180, -225 ],
      "tileWidth": 2,
      "tileHeight": 2,
      "matrixWidth": 1,
      "matrixHeight": 1
    },
    {
      "id": "8",
      "scaleDenominator": 1091958.2813060859375,
      "cellSize": 0.00274658203125,
      "pointOfOrigin": [ -180, -270 ],
      "tileWidth": 1,
      "tileHeight": 1,
      "matrixWidth": 1,
      "matrixHeight": 1
    },
    {
      "id": "9",
      "scaleDenominator": 545979.14065304296875,
      "cellSize": 0.001373291015625,
      "pointOfOrigin": [ -180, -315 ],
      "tileWidth": 1,
      "tileHeight": 1,
      "matrixWidth": 1,
      "matrixHeight": 1
    },
    {
      "id": "10",
      "scaleDenominator": 272989.570326521484375,
      "cellSize": 0.0006866455078125,
      "pointOfOrigin": [ -180, -360 ],
      "tileWidth": 1,
      "tileHeight": 1,
      "matrixWidth": 1,
      "matrixHeight": 1
    },
    {
      "id": "11",
      "scaleDenominator": 136494.7851632607421875,
      "cellSize": 0.00034332275390625,
      "pointOfOrigin": [ -180, -405 ],
      "tileWidth": 1,
      "tileHeight": 1,
      "matrixWidth": 1,
      "matrixHeight": 1
    },
    {
      "id": "12",
      "scaleDenominator": 68247.39258163037109375,
      "cellSize": 0.000171661376953125,
      "pointOfOrigin": [ -180, -450 ],
      "tileWidth": 1,
      "tileHeight": 1,
      "matrixWidth": 1,
      "matrixHeight": 1
    },
    {
      "id": "13",
      "scaleDenominator": 34123.696290815185546875,
      "cellSize": 8.58306884765625e-05,
      "pointOfOrigin": [ -180, -495 ],
      "tileWidth": 1,
      "tileHeight": 1,
      "matrixWidth": 1,
      "matrixHeight": 1
    },
    {
      "id": "14",
      "scaleDenominator": 17061.8481454075927734375,
      "cellSize": 4.291534423828125e-05,
      "pointOfOrigin": [ -180, -540 ],
      "tileWidth": 1,
      "tileHeight": 1,
      "matrixWidth": 1,
      "matrixHeight": 1
    },
    {
      "id": "15",
      "scaleDenominator": 8530.92407270379638671875,
      "cellSize": 2.1457672119140625e-05,
      "pointOfOrigin": [ -180, -585 ],
      "tileWidth": 1,
      "tileHeight": 1,
      "matrixWidth": 1,
      "matrixHeight": 1
    },
    {
      "id": "16",
      "scaleDenominator": 4265.462036351898193359375,
      "cellSize": 1.0728836059570312e-05,
      "pointOfOrigin": [ -180, -630 ],
      "tileWidth": 1,
      "tileHeight": 1,
      "matrixWidth": 1,
      "matrixHeight": 1
    },
    {
      "id": "17",
      "scaleDenominator": 2132.7310181759490966796875,
      "cellSize": 5.364418029785156e-06,
      "pointOfOrigin": [ -180, -675 ],
      "tileWidth": 1,
      "tileHeight": 1,
      "matrixWidth": 1,
      "matrixHeight": 1
    },
    {
      "id": "18",
      "scaleDenominator": 1066.36550908797454833984375,
      "cellSize": 2.682209014892578e-06,
      "pointOfOrigin": [ -180, -720 ],
      "tileWidth": 1,
      "tileHeight": 1,
      "matrixWidth": 1,
      "matrixHeight": 1
    },
    {
      "id": "19",
      "scaleDenominator": 533.182754543987274169921875,
      "cellSize": 1.341104507446289e-06,
      "pointOfOrigin": [ -180, -765 ],
      "tileWidth": 1,
      "tileHeight": 1,
      "matrixWidth": 1,
      "matrixHeight": 1
    },
    {
      "id": "20",
      "scaleDenominator": 266.5913772719936370849609375,
      "cellSize": 6.705522537223445e-07,
      "pointOfOrigin": [ -180, -810 ],
      "tileWidth": 1,
      "tileHeight": 1,
      "matrixWidth": 1,
      "matrixHeight": 1
    },
    {
      "id": "21",
      "scaleDenominator": 133.295688635976818542480484375,
      "cellSize": 3.3527612686117225e-07,
      "pointOfOrigin": [ -180, -855 ],
      "tileWidth": 1,
      "tileHeight": 1,
      "matrixWidth": 1,
      "matrixHeight": 1
    },
    {
      "id": "22",
      "scaleDenominator": 66.6477994953056,
      "cellSize": 1.6763806343058612e-07,
      "pointOfOrigin": [ -180, -900 ],
      "tileWidth": 1,
      "tileHeight": 1,
      "matrixWidth": 1,
      "matrixHeight": 1
    },
    {
      "id": "23",
      "scaleDenominator": 33.3238997476528,
      "cellSize": 8.381903171529306e-08,
      "pointOfOrigin": [ -180, -945 ],
      "tileWidth": 1,
      "tileHeight": 1,
      "matrixWidth": 1,
      "matrixHeight": 1
    }
  ]
}
```

```

    "scaleDenominator": 139770566.007179,
    "cellSize": 0.3515625,
    "pointOfOrigin": [ -180, 90 ],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 4,
    "matrixHeight": 2
},
{
    "id": "2",
    "scaleDenominator": 69885283.0035897,
    "cellSize": 0.17578125,
    "pointOfOrigin": [ -180, 90 ],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 8,
    "matrixHeight": 4
},
{
    "id": "3",
    "scaleDenominator": 34942641.5017948,
    "cellSize": 0.087890625,
    "pointOfOrigin": [ -180, 90 ],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 16,
    "matrixHeight": 8
},
{
    "id": "4",
    "scaleDenominator": 17471320.7508974,
    "cellSize": 0.0439453125,
    "pointOfOrigin": [ -180, 90 ],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 32,
    "matrixHeight": 16
},
{
    "id": "5",
    "scaleDenominator": 8735660.37544871,
    "cellSize": 0.02197265625,
    "pointOfOrigin": [ -180, 90 ],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 64,
    "matrixHeight": 32
},
{
    "id": "6",
    "scaleDenominator": 4367830.18772435,
    "cellSize": 0.010986328125,
    "pointOfOrigin": [ -180, 90 ],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 128,
    "matrixHeight": 64
},
{
    "id": "7",
    "scaleDenominator": 2183915.09386217,
    "cellSize": 0.0054931640625,
    "pointOfOrigin": [ -180, 90 ],

```

```

        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 256,
        "matrixHeight": 128
    },
    {
        "id": "8",
        "scaleDenominator": 1091957.54693108,
        "cellSize": 0.00274658203125,
        "pointOfOrigin": [ -180, 90 ],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 512,
        "matrixHeight": 256
    },
    {
        "id": "9",
        "scaleDenominator": 545978.773465544,
        "cellSize": 0.001373291015625,
        "pointOfOrigin": [ -180, 90 ],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 1024,
        "matrixHeight": 512
    },
    {
        "id": "10",
        "scaleDenominator": 272989.386732772,
        "cellSize": 0.0006866455078125,
        "pointOfOrigin": [ -180, 90 ],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 2048,
        "matrixHeight": 1024
    },
    {
        "id": "11",
        "scaleDenominator": 136494.693366386,
        "cellSize": 0.00034332275390625,
        "pointOfOrigin": [ -180, 90 ],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 4096,
        "matrixHeight": 2048
    },
    {
        "id": "12",
        "scaleDenominator": 68247.346683193,
        "cellSize": 0.000171661376953125,
        "pointOfOrigin": [ -180, 90 ],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 8192,
        "matrixHeight": 4096
    },
    {
        "id": "13",
        "scaleDenominator": 34123.6733415964,
        "cellSize": 0.0000858306884765625,
        "pointOfOrigin": [ -180, 90 ],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 16384,

```

```

        "matrixHeight": 8192
    },
    {
        "id": "14",
        "scaleDenominator": 17061.8366707982,
        "cellSize": 0.0000429153442382812,
        "pointOfOrigin": [ -180, 90 ],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 32768,
        "matrixHeight": 16384
    },
    {
        "id": "15",
        "scaleDenominator": 8530.91833539913,
        "cellSize": 0.0000214576721191406,
        "pointOfOrigin": [ -180, 90 ],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 65536,
        "matrixHeight": 32768
    },
    {
        "id": "16",
        "scaleDenominator": 4265.45916769956,
        "cellSize": 0.0000107288360595703,
        "pointOfOrigin": [ -180, 90 ],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 131072,
        "matrixHeight": 65536
    },
    {
        "id": "17",
        "scaleDenominator": 2132.72958384978,
        "cellSize": 0.00000536441802978515,
        "pointOfOrigin": [ -180, 90 ],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 262144,
        "matrixHeight": 131072
    },
    {
        "id": "18",
        "scaleDenominator": 1066.36479192489,
        "cellSize": 0.00000268220901489258,
        "pointOfOrigin": [ -180, 90 ],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 524288,
        "matrixHeight": 262144
    },
    {
        "id": "19",
        "scaleDenominator": 533.182395962445,
        "cellSize": 0.00000134110450744629,
        "pointOfOrigin": [ -180, 90 ],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 1048576,
        "matrixHeight": 524288
    },
    {

```

```

        "id": "20",
        "scaleDenominator": 266.591197981222,
        "cellSize": 0.00000067055225372314,
        "pointOfOrigin": [ -180, 90 ],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 2097152,
        "matrixHeight": 1048576
    },
    {
        "id": "21",
        "scaleDenominator": 133.295598990611,
        "cellSize": 0.00000033527612686157,
        "pointOfOrigin": [ -180, 90 ],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 4194304,
        "matrixHeight": 2097152
    },
    {
        "id": "22",
        "scaleDenominator": 66.6477994953056,
        "cellSize": 0.00000016763806343079,
        "pointOfOrigin": [ -180, 90 ],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 8388608,
        "matrixHeight": 4194304
    },
    {
        "id": "23",
        "scaleDenominator": 33.3238997476528,
        "cellSize": 0.00000008381903171539,
        "pointOfOrigin": [ -180, 90 ],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 16777216,
        "matrixHeight": 8388608
    }
]
}

```

F.4.2. World CRS84 Quad (recommended, XML encoding)

```

<?xml version="1.0" encoding="UTF-8"?>
<TileMatrixSet id="WorldCRS84Quad" xmlns="http://www.opengis.net/tms/2.0"
  xmlns:tmSc="http://www.opengis.net/tms/2.0/common" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="http://www.opengis.net/tms/2.0 ../../tilematrixset.xsd">
  <tmSc:Title>CRS84 for the World</tmSc:Title>
  <tmSc:Identifier>WorldCRS84Quad</tmSc:Identifier>
  <uri>http://www.opengis.net/def/tilematrixset/OGC/1.0/WorldCRS84Quad</uri>
  <tmSc:CRS>
    <tmSc:URI>http://www.opengis.net/def/crs/OGC/1.3/CRS84</tmSc:URI>
  </tmSc:CRS>
  <OrderedAxes>Lon,Lat</OrderedAxes>
  <WellKnownScaleSet>http://www.opengis.net/def/wkss/OGC/1.0/GoogleCRS84Quad</WellKnownScaleSet>
    <TileMatrix>
      <tmSc:Identifier>0</tmSc:Identifier>
      <ScaleDenominator>279541132.014358</ScaleDenominator>
    
```

```

<CellSize>0.703125</CellSize>
<PointOfOrigin>-180 90</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>2</MatrixWidth>
<MatrixHeight>1</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>1</tmsc:Identifier>
  <ScaleDenominator>139770566.007179</ScaleDenominator>
  <CellSize>0.3515625</CellSize>
  <PointOfOrigin>-180 90</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>4</MatrixWidth>
  <MatrixHeight>2</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>2</tmsc:Identifier>
  <ScaleDenominator>69885283.0035897</ScaleDenominator>
  <CellSize>0.17578125</CellSize>
  <PointOfOrigin>-180 90</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>8</MatrixWidth>
  <MatrixHeight>4</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>3</tmsc:Identifier>
  <ScaleDenominator>34942641.5017948</ScaleDenominator>
  <CellSize>0.087890625</CellSize>
  <PointOfOrigin>-180 90</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>16</MatrixWidth>
  <MatrixHeight>8</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>4</tmsc:Identifier>
  <ScaleDenominator>17471320.7508974</ScaleDenominator>
  <CellSize>0.0439453125</CellSize>
  <PointOfOrigin>-180 90</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>32</MatrixWidth>
  <MatrixHeight>16</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>5</tmsc:Identifier>
  <ScaleDenominator>8735660.37544871</ScaleDenominator>
  <CellSize>0.02197265625</CellSize>
  <PointOfOrigin>-180 90</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>64</MatrixWidth>
  <MatrixHeight>32</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>6</tmsc:Identifier>
  <ScaleDenominator>4367830.18772435</ScaleDenominator>
  <CellSize>0.010986328125</CellSize>
  <PointOfOrigin>-180 90</PointOfOrigin>
  <TileWidth>256</TileWidth>

```

```

<TileHeight>256</TileHeight>
<MatrixWidth>128</MatrixWidth>
<MatrixHeight>64</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>7</tmsc:Identifier>
  <ScaleDenominator>2183915.09386217</ScaleDenominator>
  <CellSize>0.0054931640625</CellSize>
  <PointOfOrigin>-180 90</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>256</MatrixWidth>
  <MatrixHeight>128</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>8</tmsc:Identifier>
  <ScaleDenominator>1091957.54693108</ScaleDenominator>
  <CellSize>0.00274658203125</CellSize>
  <PointOfOrigin>-180 90</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>512</MatrixWidth>
  <MatrixHeight>256</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>9</tmsc:Identifier>
  <ScaleDenominator>545978.773465544</ScaleDenominator>
  <CellSize>0.001373291015625</CellSize>
  <PointOfOrigin>-180 90</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>1024</MatrixWidth>
  <MatrixHeight>512</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>10</tmsc:Identifier>
  <ScaleDenominator>272989.386732772</ScaleDenominator>
  <CellSize>0.0006866455078125</CellSize>
  <PointOfOrigin>-180 90</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>2048</MatrixWidth>
  <MatrixHeight>1024</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>11</tmsc:Identifier>
  <ScaleDenominator>136494.693366386</ScaleDenominator>
  <CellSize>0.00034332275390625</CellSize>
  <PointOfOrigin>-180 90</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>4096</MatrixWidth>
  <MatrixHeight>2048</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>12</tmsc:Identifier>
  <ScaleDenominator>68247.346683193</ScaleDenominator>
  <CellSize>0.000171661376953125</CellSize>
  <PointOfOrigin>-180 90</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>8192</MatrixWidth>
  <MatrixHeight>4096</MatrixHeight>
</TileMatrix>

```

```

    </TileMatrix>
<TileMatrix>
    <tmsc:Identifier>13</tmsc:Identifier>
    <ScaleDenominator>34123.6733415964</ScaleDenominator>
    <CellSize>0.0000858306884765625</CellSize>
    <PointOfOrigin>-180 90</PointOfOrigin>
    <TileWidth>256</TileWidth>
    <TileHeight>256</TileHeight>
    <MatrixWidth>16384</MatrixWidth>
    <MatrixHeight>8192</MatrixHeight>
</TileMatrix>
<TileMatrix>
    <tmsc:Identifier>14</tmsc:Identifier>
    <ScaleDenominator>17061.8366707982</ScaleDenominator>
    <CellSize>0.0000429153442382812</CellSize>
    <PointOfOrigin>-180 90</PointOfOrigin>
    <TileWidth>256</TileWidth>
    <TileHeight>256</TileHeight>
    <MatrixWidth>32768</MatrixWidth>
    <MatrixHeight>16384</MatrixHeight>
</TileMatrix>
<TileMatrix>
    <tmsc:Identifier>15</tmsc:Identifier>
    <ScaleDenominator>8530.91833539913</ScaleDenominator>
    <CellSize>0.0000214576721191406</CellSize>
    <PointOfOrigin>-180 90</PointOfOrigin>
    <TileWidth>256</TileWidth>
    <TileHeight>256</TileHeight>
    <MatrixWidth>65536</MatrixWidth>
    <MatrixHeight>32768</MatrixHeight>
</TileMatrix>
<TileMatrix>
    <tmsc:Identifier>16</tmsc:Identifier>
    <ScaleDenominator>4265.45916769956</ScaleDenominator>
    <CellSize>0.0000107288360595703</CellSize>
    <PointOfOrigin>-180 90</PointOfOrigin>
    <TileWidth>256</TileWidth>
    <TileHeight>256</TileHeight>
    <MatrixWidth>131072</MatrixWidth>
    <MatrixHeight>65536</MatrixHeight>
</TileMatrix>
<TileMatrix>
    <tmsc:Identifier>17</tmsc:Identifier>
    <ScaleDenominator>2132.72958384978</ScaleDenominator>
    <CellSize>0.00000536441802978515</CellSize>
    <PointOfOrigin>-180 90</PointOfOrigin>
    <TileWidth>256</TileWidth>
    <TileHeight>256</TileHeight>
    <MatrixWidth>262144</MatrixWidth>
    <MatrixHeight>131072</MatrixHeight>
</TileMatrix>
<TileMatrix>
    <tmsc:Identifier>18</tmsc:Identifier>
    <ScaleDenominator>1066.36479192489</ScaleDenominator>
    <CellSize>0.00000268220901489258</CellSize>
    <PointOfOrigin>-180 90</PointOfOrigin>
    <TileWidth>256</TileWidth>
    <TileHeight>256</TileHeight>
    <MatrixWidth>524288</MatrixWidth>
    <MatrixHeight>262144</MatrixHeight>
</TileMatrix>
<TileMatrix>
    <tmsc:Identifier>19</tmsc:Identifier>

```

```

<ScaleDenominator>533.182395962445</ScaleDenominator>
<CellSize>0.00000134110450744629</CellSize>
<PointOfOrigin>-180 90</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>1048576</MatrixWidth>
<MatrixHeight>524288</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>20</tmsc:Identifier>
  <ScaleDenominator>266.591197981222</ScaleDenominator>
  <CellSize>0.000000670552253723144</CellSize>
  <PointOfOrigin>-180 90</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>2097152</MatrixWidth>
  <MatrixHeight>1048576</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>21</tmsc:Identifier>
  <ScaleDenominator>133.295598990611</ScaleDenominator>
  <CellSize>0.000000335276126861572</CellSize>
  <PointOfOrigin>-180 90</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>4194304</MatrixWidth>
  <MatrixHeight>2097152</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>22</tmsc:Identifier>
  <ScaleDenominator>66.6477994953056</ScaleDenominator>
  <CellSize>0.000000167638063430786</CellSize>
  <PointOfOrigin>-180 90</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>8388608</MatrixWidth>
  <MatrixHeight>4194304</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>23</tmsc:Identifier>
  <ScaleDenominator>33.3238997476528</ScaleDenominator>
  <CellSize>0.000000083819031715393</CellSize>
  <PointOfOrigin>-180 90</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>16777216</MatrixWidth>
  <MatrixHeight>8388608</MatrixHeight>
</TileMatrix>
</TileMatrixSet>

```

Variant 2: World EPSG:4326 Quad

These are the JSON and XML definitions of the WorldCRS84Quad tile matrix based on EPSG:4326 (see Annex D.2.2) that can be reproduced by other standards needing to define a tile matrix set. Not all TileMatrix elements need to be included and including other TileMatrices for more detailed scales is possible if they follow the same pattern.

One can define an arbitrary number of zoom levels. Here, 23 zoom levels are illustrated.

F.4.3. World EPSG:4326 Quad (JSON encoding)

```
{  
    "id": "WorldCRS84Quad",  
    "title": "EPSG:4326 for the World",  
    "uri": "http://www.opengis.net/def/tilematrixset/OGC/1.0/WorldCRS84Quad",  
    "crs": "http://www.opengis.net/def/crs/EPSG/0/4326",  
    "orderedAxes": [ "Lat", "Lon" ],  
    "wellKnownScaleSet": "http://www.opengis.net/def/wkss/OGC/1.0/  
GoogleCRS84Quad",  
    "tileMatrices": [  
        {  
            "id": "0",  
            "scaleDenominator": 279541132.014358,  
            "cellSize": 0.703125,  
            "pointOfOrigin": [ 90, -180 ],  
            "tileWidth": 256,  
            "tileHeight": 256,  
            "matrixWidth": 2,  
            "matrixHeight": 1  
        },  
        {  
            "id": "1",  
            "scaleDenominator": 139770566.007179,  
            "cellSize": 0.3515625,  
            "pointOfOrigin": [ 90, -180 ],  
            "tileWidth": 256,  
            "tileHeight": 256,  
            "matrixWidth": 4,  
            "matrixHeight": 2  
        },  
        {  
            "id": "2",  
            "scaleDenominator": 69885283.0035897,  
            "cellSize": 0.17578125,  
            "pointOfOrigin": [ 90, -180 ],  
            "tileWidth": 256,  
            "tileHeight": 256,  
            "matrixWidth": 8,  
            "matrixHeight": 4  
        },  
        {  
            "id": "3",  
            "scaleDenominator": 34942641.5017948,  
            "cellSize": 0.087890625,  
            "pointOfOrigin": [ 90, -180 ],  
            "tileWidth": 256,  
            "tileHeight": 256,  
            "matrixWidth": 16,  
            "matrixHeight": 8  
        },  
        {  
            "id": "4",  
            "scaleDenominator": 17471320.7508974,  
            "cellSize": 0.0439453125,  
            "pointOfOrigin": [ 90, -180 ],  
            "tileWidth": 256,  
            "tileHeight": 256,  
            "matrixWidth": 32,  
            "matrixHeight": 16  
        }  
    ]  
}
```

```

},
{
  "id": "5",
  "scaleDenominator": 8735660.37544871,
  "cellSize": 0.02197265625,
  "pointOfOrigin": [ 90, -180],
  "tileWidth": 256,
  "tileHeight": 256,
  "matrixWidth": 64,
  "matrixHeight": 32
},
{
  "id": "6",
  "scaleDenominator": 4367830.18772435,
  "cellSize": 0.010986328125,
  "pointOfOrigin": [ 90, -180],
  "tileWidth": 256,
  "tileHeight": 256,
  "matrixWidth": 128,
  "matrixHeight": 64
},
{
  "id": "7",
  "scaleDenominator": 2183915.09386217,
  "cellSize": 0.0054931640625,
  "pointOfOrigin": [ 90, -180],
  "tileWidth": 256,
  "tileHeight": 256,
  "matrixWidth": 256,
  "matrixHeight": 128
},
{
  "id": "8",
  "scaleDenominator": 1091957.54693108,
  "cellSize": 0.00274658203125,
  "pointOfOrigin": [ 90, -180],
  "tileWidth": 256,
  "tileHeight": 256,
  "matrixWidth": 512,
  "matrixHeight": 256
},
{
  "id": "9",
  "scaleDenominator": 545978.773465544,
  "cellSize": 0.001373291015625,
  "pointOfOrigin": [ 90, -180],
  "tileWidth": 256,
  "tileHeight": 256,
  "matrixWidth": 1024,
  "matrixHeight": 512
},
{
  "id": "10",
  "scaleDenominator": 272989.386732772,
  "cellSize": 0.0006866455078125,
  "pointOfOrigin": [ 90, -180],
  "tileWidth": 256,
  "tileHeight": 256,
  "matrixWidth": 2048,
  "matrixHeight": 1024
},
{
  "id": "11",

```

```

    "scaleDenominator": 136494.693366386,
    "cellSize": 0.00034332275390625,
    "pointOfOrigin": [ 90, -180],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 4096,
    "matrixHeight": 2048
},
{
    "id": "12",
    "scaleDenominator": 68247.346683193,
    "cellSize": 0.000171661376953125,
    "pointOfOrigin": [ 90, -180],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 8192,
    "matrixHeight": 4096
},
{
    "id": "13",
    "scaleDenominator": 34123.6733415964,
    "cellSize": 0.0000858306884765625,
    "pointOfOrigin": [ 90, -180],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 16384,
    "matrixHeight": 8192
},
{
    "id": "14",
    "scaleDenominator": 17061.8366707982,
    "cellSize": 0.0000429153442382812,
    "pointOfOrigin": [ 90, -180],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 32768,
    "matrixHeight": 16384
},
{
    "id": "15",
    "scaleDenominator": 8530.91833539913,
    "cellSize": 0.0000214576721191406,
    "pointOfOrigin": [ 90, -180],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 65536,
    "matrixHeight": 32768
},
{
    "id": "16",
    "scaleDenominator": 4265.45916769956,
    "cellSize": 0.0000107288360595703,
    "pointOfOrigin": [ 90, -180],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 131072,
    "matrixHeight": 65536
},
{
    "id": "17",
    "scaleDenominator": 2132.72958384978,
    "cellSize": 0.00000536441802978515,
    "pointOfOrigin": [ 90, -180],

```

```

        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 262144,
        "matrixHeight": 131072
    },
    {
        "id": "18",
        "scaleDenominator": 1066.36479192489,
        "cellSize": 0.00000268220901489258,
        "pointOfOrigin": [ 90, -180],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 524288,
        "matrixHeight": 262144
    },
    {
        "id": "19",
        "scaleDenominator": 533.182395962445,
        "cellSize": 0.00000134110450744629,
        "pointOfOrigin": [ 90, -180],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 1048576,
        "matrixHeight": 524288
    },
    {
        "id": "20",
        "scaleDenominator": 266.591197981222,
        "cellSize": 0.00000067055225372314,
        "pointOfOrigin": [ 90, -180],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 2097152,
        "matrixHeight": 1048576
    },
    {
        "id": "21",
        "scaleDenominator": 133.295598990611,
        "cellSize": 0.00000033527612686157,
        "pointOfOrigin": [ 90, -180],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 4194304,
        "matrixHeight": 2097152
    },
    {
        "id": "22",
        "scaleDenominator": 66.6477994953056,
        "cellSize": 0.00000016763806343079,
        "pointOfOrigin": [ 90, -180],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 8388608,
        "matrixHeight": 4194304
    },
    {
        "id": "23",
        "scaleDenominator": 33.3238997476528,
        "cellSize": 0.00000008381903171539,
        "pointOfOrigin": [ 90, -180],           "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 16777216,
        "matrixHeight": 8388608
    }

```

```
        }
    ]
}
```

F.4.4. World EPSG:4326 Quad (XML encoding)

```
<?xml version="1.0" encoding="UTF-8"?>
<TileMatrixSet id="WorldCRS84Quad" xmlns="http://www.opengis.net/tms/2.0"
  xmlns:tmsc="http://www.opengis.net/tms/2.0/common" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="http://www.opengis.net/tms/2.0 ../../tilematrixset.xsd">
  <tmsc:Title>EPSG:4326 for the World</tmsc:Title>
  <tmsc:Identifier>WorldCRS84Quad</tmsc:Identifier>
  <uri>http://www.opengis.net/def/tilematrixset/OGC/1.0/WorldCRS84Quad</uri>
  <tmsc:CRS>
    <tmsc:URI>http://www.opengis.net/def/crs/EPSC/0/4326</tmsc:URI>
  </tmsc:CRS>
  <OrderedAxes>Lat,Lon</OrderedAxes>
  <WellKnownScaleSet>http://www.opengis.net/def/wkss/OGC/1.0/GoogleCRS84Quad</WellKnownScaleSet>
  <TileMatrix>
    <tmsc:Identifier>0</tmsc:Identifier>
    <ScaleDenominator>279541132.014358</ScaleDenominator>
    <CellSize>0.703125</CellSize>
    <PointOfOrigin>90 -180</PointOfOrigin>
    <TileWidth>256</TileWidth>
    <TileHeight>256</TileHeight>
    <MatrixWidth>2</MatrixWidth>
    <MatrixHeight>1</MatrixHeight>
  </TileMatrix>
  <TileMatrix>
    <tmsc:Identifier>1</tmsc:Identifier>
    <ScaleDenominator>139770566.007179</ScaleDenominator>
    <CellSize>0.3515625</CellSize>
    <PointOfOrigin>90 -180</PointOfOrigin>
    <TileWidth>256</TileWidth>
    <TileHeight>256</TileHeight>
    <MatrixWidth>4</MatrixWidth>
    <MatrixHeight>2</MatrixHeight>
  </TileMatrix>
  <TileMatrix>
    <tmsc:Identifier>2</tmsc:Identifier>
    <ScaleDenominator>69885283.0035897</ScaleDenominator>
    <CellSize>0.17578125</CellSize>
    <PointOfOrigin>90 -180</PointOfOrigin>
    <TileWidth>256</TileWidth>
    <TileHeight>256</TileHeight>
    <MatrixWidth>8</MatrixWidth>
    <MatrixHeight>4</MatrixHeight>
  </TileMatrix>
  <TileMatrix>
    <tmsc:Identifier>3</tmsc:Identifier>
    <ScaleDenominator>34942641.5017948</ScaleDenominator>
    <CellSize>0.087890625</CellSize>
    <PointOfOrigin>90 -180</PointOfOrigin>
    <TileWidth>256</TileWidth>
    <TileHeight>256</TileHeight>
    <MatrixWidth>16</MatrixWidth>
    <MatrixHeight>8</MatrixHeight>
  </TileMatrix>
  <TileMatrix>
```

```

<tmsc:Identifier>4</tmsc:Identifier>
<ScaleDenominator>17471320.7508974</ScaleDenominator>
<CellSize>0.0439453125</CellSize>
<PointOfOrigin>90 -180</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>32</MatrixWidth>
<MatrixHeight>16</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>5</tmsc:Identifier>
<ScaleDenominator>8735660.37544871</ScaleDenominator>
<CellSize>0.02197265625</CellSize>
<PointOfOrigin>90 -180</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>64</MatrixWidth>
<MatrixHeight>32</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>6</tmsc:Identifier>
<ScaleDenominator>4367830.18772435</ScaleDenominator>
<CellSize>0.010986328125</CellSize>
<PointOfOrigin>90 -180</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>128</MatrixWidth>
<MatrixHeight>64</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>7</tmsc:Identifier>
<ScaleDenominator>2183915.09386217</ScaleDenominator>
<CellSize>0.0054931640625</CellSize>
<PointOfOrigin>90 -180</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>256</MatrixWidth>
<MatrixHeight>128</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>8</tmsc:Identifier>
<ScaleDenominator>1091957.54693108</ScaleDenominator>
<CellSize>0.00274658203125</CellSize>
<PointOfOrigin>90 -180</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>512</MatrixWidth>
<MatrixHeight>256</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>9</tmsc:Identifier>
<ScaleDenominator>545978.773465544</ScaleDenominator>
<CellSize>0.001373291015625</CellSize>
<PointOfOrigin>90 -180</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>1024</MatrixWidth>
<MatrixHeight>512</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>10</tmsc:Identifier>
<ScaleDenominator>272989.386732772</ScaleDenominator>
<CellSize>0.0006866455078125</CellSize>

```

```

<PointOfOrigin>90 -180</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>2048</MatrixWidth>
<MatrixHeight>1024</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>11</tmsc:Identifier>
  <ScaleDenominator>136494.693366386</ScaleDenominator>
  <CellSize>0.00034332275390625</CellSize>
  <PointOfOrigin>90 -180</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>4096</MatrixWidth>
  <MatrixHeight>2048</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>12</tmsc:Identifier>
  <ScaleDenominator>68247.346683193</ScaleDenominator>
  <CellSize>0.000171661376953125</CellSize>
  <PointOfOrigin>90 -180</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>8192</MatrixWidth>
  <MatrixHeight>4096</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>13</tmsc:Identifier>
  <ScaleDenominator>34123.6733415964</ScaleDenominator>
  <CellSize>0.0000858306884765625</CellSize>
  <PointOfOrigin>90 -180</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>16384</MatrixWidth>
  <MatrixHeight>8192</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>14</tmsc:Identifier>
  <ScaleDenominator>17061.8366707982</ScaleDenominator>
  <CellSize>0.0000429153442382812</CellSize>
  <PointOfOrigin>90 -180</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>32768</MatrixWidth>
  <MatrixHeight>16384</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>15</tmsc:Identifier>
  <ScaleDenominator>8530.91833539913</ScaleDenominator>
  <CellSize>0.0000214576721191406</CellSize>
  <PointOfOrigin>90 -180</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>65536</MatrixWidth>
  <MatrixHeight>32768</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>16</tmsc:Identifier>
  <ScaleDenominator>4265.45916769956</ScaleDenominator>
  <CellSize>0.0000107288360595703</CellSize>
  <PointOfOrigin>90 -180</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>

```

```

<MatrixWidth>131072</MatrixWidth>
<MatrixHeight>65536</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>17</tmsc:Identifier>
  <ScaleDenominator>2132.72958384978</ScaleDenominator>
  <CellSize>0.00000536441802978515</CellSize>
  <PointOfOrigin>90 -180</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>262144</MatrixWidth>
  <MatrixHeight>131072</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>18</tmsc:Identifier>
  <ScaleDenominator>1066.36479192489</ScaleDenominator>
  <CellSize>0.00000268220901489258</CellSize>
  <PointOfOrigin>90 -180</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>524288</MatrixWidth>
  <MatrixHeight>262144</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>19</tmsc:Identifier>
  <ScaleDenominator>533.182395962445</ScaleDenominator>
  <CellSize>0.00000134110450744629</CellSize>
  <PointOfOrigin>90 -180</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>1048576</MatrixWidth>
  <MatrixHeight>524288</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>20</tmsc:Identifier>
  <ScaleDenominator>266.591197981222</ScaleDenominator>
  <CellSize>0.000000670552253723144</CellSize>
  <PointOfOrigin>90 -180</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>2097152</MatrixWidth>
  <MatrixHeight>1048576</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>21</tmsc:Identifier>
  <ScaleDenominator>133.295598990611</ScaleDenominator>
  <CellSize>0.000000335276126861572</CellSize>
  <PointOfOrigin>90 -180</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>4194304</MatrixWidth>
  <MatrixHeight>2097152</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>22</tmsc:Identifier>
  <ScaleDenominator>66.6477994953056</ScaleDenominator>
  <CellSize>0.000000167638063430786</CellSize>
  <PointOfOrigin>90 -180</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>8388608</MatrixWidth>
  <MatrixHeight>4194304</MatrixHeight>
</TileMatrix>

```

```

<TileMatrix>
  <tmsc:Identifier>23</tmsc:Identifier>
  <ScaleDenominator>33.3238997476528</ScaleDenominator>
  <CellSize>0.00000083819031715393</CellSize>
  <PointOfOrigin>90 -180</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>16777216</MatrixWidth>
  <MatrixHeight>8388608</MatrixHeight>
</TileMatrix>
</TileMatrixSet>

```

F.5. World Mercator WGS84 Quad

These are the JSON and XML definitions of the WorldMercatorWGS84Quad tile matrix set (see Annex D.3) that can be reproduced by other standards needing to define a tile matrix set. Not all TileMatrix elements need to be included and including other TileMatrices for more detailed scales is possible if they follow the same pattern.

One can define an arbitrary number of zoom levels. Here, 19 zoom levels are illustrated but resolutions up to 24 are currently available in some mass market services.

F.5.1. World Mercator WGS84 Quad (JSON encoding)

```
{
  "id": "WorldMercatorWGS84Quad",
  "title": "World Mercator WGS84 (ellipsoid)",
  "uri": "http://www.opengis.net/def/tilematrixset/OGC/1.0/
WorldMercatorWGS84Quad",
  "crs": "http://www.opengis.net/def/crs/EPSG/0/3395",
  "orderedAxes": ["E", "N"],
  "wellKnownScaleSet": "http://www.opengis.net/def/wkss/OGC/1.0/
WorldMercatorWGS84",
  "tileMatrices":
  [
    {
      "id": "0",
      "scaleDenominator": 559082264.028717,
      "cellSize": 156543.033928041,
      "pointOfOrigin": [-20037508.3427892, 20037508.3427892],
      "tileWidth": 256,
      "tileHeight": 256,
      "matrixWidth": 1,
      "matrixHeight": 1
    },
    {
      "id": "1",
      "scaleDenominator": 279541132.014358,
      "cellSize": 78271.5169640204,
      "pointOfOrigin": [-20037508.3427892, 20037508.3427892],
      "tileWidth": 256,
      "tileHeight": 256,
      "matrixWidth": 2,
      "matrixHeight": 2
    }
  ]
}
```

```

},
{
  "id": "2",
  "scaleDenominator": 139770566.007179,
  "cellSize": 39135.7584820102,
  "pointOfOrigin": [-20037508.3427892,20037508.3427892],
  "tileWidth": 256,
  "tileHeight": 256,
  "matrixWidth": 4,
  "matrixHeight": 4
},
{
  "id": "3",
  "scaleDenominator": 69885283.0035897,
  "cellSize": 19567.8792410051,
  "pointOfOrigin": [-20037508.3427892,20037508.3427892],
  "tileWidth": 256,
  "tileHeight": 256,
  "matrixWidth": 8,
  "matrixHeight": 8
},
{
  "id": "4",
  "scaleDenominator": 34942641.5017948,
  "cellSize": 9783.93962050256,
  "pointOfOrigin": [-20037508.3427892,20037508.3427892],
  "tileWidth": 256,
  "tileHeight": 256,
  "matrixWidth": 16,
  "matrixHeight": 16
},
{
  "id": "5",
  "scaleDenominator": 17471320.7508974,
  "cellSize": 4891.96981025128,
  "pointOfOrigin": [-20037508.3427892,20037508.3427892],
  "tileWidth": 256,
  "tileHeight": 256,
  "matrixWidth": 32,
  "matrixHeight": 32
},
{
  "id": "6",
  "scaleDenominator": 8735660.37544871,
  "cellSize": 2445.98490512564,
  "pointOfOrigin": [-20037508.3427892,20037508.3427892],
  "tileWidth": 256,
  "tileHeight": 256,
  "matrixWidth": 64,
  "matrixHeight": 64
},
{
  "id": "7",
  "scaleDenominator": 4367830.18772435,
  "cellSize": 1222.99245256282,
  "pointOfOrigin": [-20037508.3427892,20037508.3427892],
  "tileWidth": 256,
  "tileHeight": 256,
  "matrixWidth": 128,
  "matrixHeight": 128
},
{
  "id": "8",

```

```

    "scaleDenominator": 2183915.09386217,
    "cellSize": 611.49622628141,
    "pointOfOrigin": [-20037508.3427892,20037508.3427892],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 256,
    "matrixHeight": 256
},
{
    "id": "9",
    "scaleDenominator": 1091957.54693108,
    "cellSize": 305.748113140704,
    "pointOfOrigin": [-20037508.3427892,20037508.3427892],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 512,
    "matrixHeight": 512
},
{
    "id": "10",
    "scaleDenominator": 545978.773465544,
    "cellSize": 152.874056570352,
    "pointOfOrigin": [-20037508.3427892,20037508.3427892],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 1024,
    "matrixHeight": 1024
},
{
    "id": "11",
    "scaleDenominator": 272989.386732772,
    "cellSize": 76.4370282851762,
    "pointOfOrigin": [-20037508.3427892,20037508.3427892],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 2048,
    "matrixHeight": 2048
},
{
    "id": "12",
    "scaleDenominator": 136494.693366386,
    "cellSize": 38.2185141425881,
    "pointOfOrigin": [-20037508.3427892,20037508.3427892],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 4096,
    "matrixHeight": 4096
},
{
    "id": "13",
    "scaleDenominator": 68247.346683193,
    "cellSize": 19.109257071294,
    "pointOfOrigin": [-20037508.3427892,20037508.3427892],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 8192,
    "matrixHeight": 8192
},
{
    "id": "14",
    "scaleDenominator": 34123.6733415964,
    "cellSize": 9.55462853564703,
    "pointOfOrigin": [-20037508.3427892,20037508.3427892],

```

```

    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 16384,
    "matrixHeight": 16384
},
{
    "id": "15",
    "scaleDenominator": 17061.8366707982,
    "cellSize": 4.77731426782351,
    "pointOfOrigin": [-20037508.3427892,20037508.3427892],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 32768,
    "matrixHeight": 32768
},
{
    "id": "16",
    "scaleDenominator": 8530.91833539913,
    "cellSize": 2.38865713391175,
    "pointOfOrigin": [-20037508.3427892,20037508.3427892],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 65536,
    "matrixHeight": 65536
},
{
    "id": "17",
    "scaleDenominator": 4265.45916769956,
    "cellSize": 1.19432856695587,
    "pointOfOrigin": [-20037508.3427892,20037508.3427892],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 131072,
    "matrixHeight": 131072
},
{
    "id": "18",
    "scaleDenominator": 2132.72958384978,
    "cellSize": 0.597164283477939,
    "pointOfOrigin": [-20037508.3427892,20037508.3427892],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 262144,
    "matrixHeight": 262144
},
{
    "id": "19",
    "scaleDenominator": 1066.36479192489,
    "cellSize": 0.29858214173897,
    "pointOfOrigin": [-20037508.3427892,20037508.3427892],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 524288,
    "matrixHeight": 524288
},
{
    "id": "20",
    "scaleDenominator": 533.182395962445,
    "cellSize": 0.149291070869485,
    "pointOfOrigin": [-20037508.3427892,20037508.3427892],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 1048576,

```

```

        "matrixHeight": 1048576
    },
    {
        "id": "21",
        "scaleDenominator": 266.591197981222,
        "cellSize": 0.0746455354347424,
        "pointOfOrigin": [-20037508.3427892,20037508.3427892],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 2097152,
        "matrixHeight": 2097152
    },
    {
        "id": "22",
        "scaleDenominator": 133.295598990611,
        "cellSize": 0.0373227677173712,
        "pointOfOrigin": [-20037508.3427892,20037508.3427892],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 4194304,
        "matrixHeight": 4194304
    },
    {
        "id": "23",
        "scaleDenominator": 66.6477994953056,
        "cellSize": 0.0186613838586856,
        "pointOfOrigin": [-20037508.3427892,20037508.3427892],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 8388608,
        "matrixHeight": 8388608
    },
    {
        "id": "24",
        "scaleDenominator": 33.3238997476528,
        "cellSize": 0.0093306919293428,
        "pointOfOrigin": [-20037508.3427892,20037508.3427892],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 16777216,
        "matrixHeight": 16777216
    }
]
}

```

F.5.2. World Mercator WGS84 Quad (XML encoding)

```

<?xml version="1.0" encoding="UTF-8"?>
<TileMatrixSet id="WorldMercatorWGS84Quad" xmlns="http://www.opengis.net/tms/2.0" xmlns:tmse="http://www.opengis.net/tms/2.0/common" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="http://www.opengis.net/tms/2.0 ../../tilematrixset.xsd">
    <tmse:Title>World Mercator WGS84 (ellipsoid)</tmse:Title>
    <tmse:Identifier>WorldMercatorWGS84Quad</tmse:Identifier>
    <uri>http://www.opengis.net/def/tilematrixset/OGC/1.0/WorldMercatorWGS84Quad</uri>
    <tmse:CRS>
        <tmse:URI>http://www.opengis.net/def/crs/EPSG/0/3395</tmse:URI>
    </tmse:CRS>
    <OrderedAxes>E,N</OrderedAxes>

```

```

<WellKnownScaleSet>http://www.opengis.net/def/wkss/OGC/1.0/
WorldMercatorWGS84</WellKnownScaleSet>
<TileMatrix>
  <tmsc:Identifier>0</tmsc:Identifier>
  <ScaleDenominator>559082264.028717</ScaleDenominator>
  <CellSize>156543.033928041</CellSize>
  <PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>1</MatrixWidth>
  <MatrixHeight>1</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>1</tmsc:Identifier>
  <ScaleDenominator>279541132.014358</ScaleDenominator>
  <CellSize>78271.5169640204</CellSize>
  <PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>2</MatrixWidth>
  <MatrixHeight>2</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>2</tmsc:Identifier>
  <ScaleDenominator>139770566.007179</ScaleDenominator>
  <CellSize>39135.7584820102</CellSize>
  <PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>4</MatrixWidth>
  <MatrixHeight>4</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>3</tmsc:Identifier>
  <ScaleDenominator>69885283.0035897</ScaleDenominator>
  <CellSize>19567.8792410051</CellSize>
  <PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>8</MatrixWidth>
  <MatrixHeight>8</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>4</tmsc:Identifier>
  <ScaleDenominator>34942641.5017948</ScaleDenominator>
  <CellSize>9783.93962050256</CellSize>
  <PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>16</MatrixWidth>
  <MatrixHeight>16</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>5</tmsc:Identifier>
  <ScaleDenominator>17471320.7508974</ScaleDenominator>
  <CellSize>4891.96981025128</CellSize>
  <PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>32</MatrixWidth>
  <MatrixHeight>32</MatrixHeight>
</TileMatrix>
<TileMatrix>

```

```

<tmsc:Identifier>6</tmsc:Identifier>
<ScaleDenominator>8735660.37544871</ScaleDenominator>
<CellSize>2445.98490512564</CellSize>
<PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>64</MatrixWidth>
<MatrixHeight>64</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>7</tmsc:Identifier>
<ScaleDenominator>4367830.18772435</ScaleDenominator>
<CellSize>1222.99245256282</CellSize>
<PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>128</MatrixWidth>
<MatrixHeight>128</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>8</tmsc:Identifier>
<ScaleDenominator>2183915.09386217</ScaleDenominator>
<CellSize>611.49622628141</CellSize>
<PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>256</MatrixWidth>
<MatrixHeight>256</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>9</tmsc:Identifier>
<ScaleDenominator>1091957.54693108</ScaleDenominator>
<CellSize>305.748113140704</CellSize>
<PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>512</MatrixWidth>
<MatrixHeight>512</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>10</tmsc:Identifier>
<ScaleDenominator>545978.773465544</ScaleDenominator>
<CellSize>152.874056570352</CellSize>
<PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>1024</MatrixWidth>
<MatrixHeight>1024</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>11</tmsc:Identifier>
<ScaleDenominator>272989.386732772</ScaleDenominator>
<CellSize>76.4370282851762</CellSize>
<PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>2048</MatrixWidth>
<MatrixHeight>2048</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>12</tmsc:Identifier>
<ScaleDenominator>136494.693366386</ScaleDenominator>
<CellSize>38.2185141425881</CellSize>

```

```

<PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>4096</MatrixWidth>
<MatrixHeight>4096</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>13</tmsc:Identifier>
<ScaleDenominator>68247.346683193</ScaleDenominator>
<CellSize>19.109257071294</CellSize>
<PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>8192</MatrixWidth>
<MatrixHeight>8192</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>14</tmsc:Identifier>
<ScaleDenominator>34123.6733415964</ScaleDenominator>
<CellSize>9.55462853564703</CellSize>
<PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>16384</MatrixWidth>
<MatrixHeight>16384</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>15</tmsc:Identifier>
<ScaleDenominator>17061.8366707982</ScaleDenominator>
<CellSize>4.77731426782351</CellSize>
<PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>32768</MatrixWidth>
<MatrixHeight>32768</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>16</tmsc:Identifier>
<ScaleDenominator>8530.91833539913</ScaleDenominator>
<CellSize>2.38865713391175</CellSize>
<PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>65536</MatrixWidth>
<MatrixHeight>65536</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>17</tmsc:Identifier>
<ScaleDenominator>4265.45916769956</ScaleDenominator>
<CellSize>1.19432856695587</CellSize>
<PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>131072</MatrixWidth>
<MatrixHeight>131072</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>18</tmsc:Identifier>
<ScaleDenominator>2132.72958384978</ScaleDenominator>
<CellSize>0.597164283477939</CellSize>
<PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>

```

```

<MatrixWidth>262144</MatrixWidth>
<MatrixHeight>262144</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>19</tmsc:Identifier>
<ScaleDenominator>1066.36479192489</ScaleDenominator>
<CellSize>0.29858214173897</CellSize>
<PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>524288</MatrixWidth>
<MatrixHeight>524288</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>20</tmsc:Identifier>
<ScaleDenominator>533.182395962445</ScaleDenominator>
<CellSize>0.149291070869485</CellSize>
<PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>1048576</MatrixWidth>
<MatrixHeight>1048576</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>21</tmsc:Identifier>
<ScaleDenominator>266.591197981222</ScaleDenominator>
<CellSize>0.0746455354347424</CellSize>
<PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>2097152</MatrixWidth>
<MatrixHeight>2097152</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>22</tmsc:Identifier>
<ScaleDenominator>133.295598990611</ScaleDenominator>
<CellSize>0.0373227677173712</CellSize>
<PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>4194304</MatrixWidth>
<MatrixHeight>4194304</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>23</tmsc:Identifier>
<ScaleDenominator>66.6477994953056</ScaleDenominator>
<CellSize>0.0186613838586856</CellSize>
<PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>8388608</MatrixWidth>
<MatrixHeight>8388608</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>24</tmsc:Identifier>
<ScaleDenominator>33.3238997476528</ScaleDenominator>
<CellSize>0.0093306919293428</CellSize>
<PointOfOrigin>-20037508.3427892 20037508.3427892</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>16777216</MatrixWidth>
<MatrixHeight>16777216</MatrixHeight>
</TileMatrix>

```

```
</TileMatrixSet>
```

F.6. Universal Transverse Mercator WGS84 Quad for zone 31

These are the JSON and XML definitions of the UTM31WGS84Quad tile matrix set (see Annex D.4) that can be reproduced by other standards needing to define a tile matrix set if the zone 31 is required. The other 59 zones in the 60 UTM partition can be defined similarly. Not all TileMatrix elements need to be included and including other TileMatrices for more detailed scales is possible if they follow the same pattern.

F.6.1. UTM WGS84 Quad for zone 31 (JSON encoding)

```
{
  "id": "UTM31WGS84Quad",
  "title": "Universal Transverse Mercator Zone 31 WGS84 Quad",
  "uri": "http://www.opengis.net/def/tilematrixset/OGC/1.0/UTM31WGS84Quad",
  "crs": "http://www.opengis.net/def/crs/EPSG/0/32631",
  "orderedAxes": ["E", "N"],
  "tileMatrices": [
    {
      "id": "1",
      "scaleDenominator": 279072704.500914,
      "cellSize": 78140.3572602559,
      "pointOfOrigin": [-9501965.72931276, 20003931.4586255],
      "tileWidth": 256,
      "tileHeight": 256,
      "matrixWidth": 1,
      "matrixHeight": 2
    },
    {
      "id": "2",
      "scaleDenominator": 139536352.250457,
      "cellSize": 39070.178630128,
      "pointOfOrigin": [-9501965.72931276, 20003931.4586255],
      "tileWidth": 256,
      "tileHeight": 256,
      "matrixWidth": 2,
      "matrixHeight": 4
    },
    {
      "id": "3",
      "scaleDenominator": 69768176.1252285,
      "cellSize": 19535.089315064,
      "pointOfOrigin": [-9501965.72931276, 20003931.4586255],
      "tileWidth": 256,
      "tileHeight": 256,
      "matrixWidth": 4,
      "matrixHeight": 8
    },
    {
      "id": "4",
      "scaleDenominator": 34884088.06261425,
      "cellSize": 9767.5465762816,
      "pointOfOrigin": [-9501965.72931276, 20003931.4586255],
      "tileWidth": 256,
      "tileHeight": 256,
      "matrixWidth": 8,
      "matrixHeight": 16
    }
  ]
}
```

```

    "scaleDenominator": 34884088.0626143,
    "cellSize": 9767.5446575319,
    "pointOfOrigin": [-9501965.72931276,20003931.4586255],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 8,
    "matrixHeight": 16
},
{
    "id": "5",
    "scaleDenominator": 17442044.0313071,
    "cellSize": 4883.772328766,
    "pointOfOrigin": [-9501965.72931276,20003931.4586255],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 16,
    "matrixHeight": 32
},
{
    "id": "6",
    "scaleDenominator": 8721022.01565356,
    "cellSize": 2441.886164383,
    "pointOfOrigin": [-9501965.72931276,20003931.4586255],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 32,
    "matrixHeight": 64
},
{
    "id": "7",
    "scaleDenominator": 4360511.00782678,
    "cellSize": 1220.9430821915,
    "pointOfOrigin": [-9501965.72931276,20003931.4586255],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 64,
    "matrixHeight": 128
},
{
    "id": "8",
    "scaleDenominator": 2180255.50391339,
    "cellSize": 610.471541095749,
    "pointOfOrigin": [-9501965.72931276,20003931.4586255],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 128,
    "matrixHeight": 256
},
{
    "id": "9",
    "scaleDenominator": 1090127.7519567,
    "cellSize": 305.235770547875,
    "pointOfOrigin": [-9501965.72931276,20003931.4586255],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 256,
    "matrixHeight": 512
},
{
    "id": "10",
    "scaleDenominator": 545063.875978348,
    "cellSize": 152.617885273937,
    "pointOfOrigin": [-9501965.72931276,20003931.4586255],

```

```

    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 512,
    "matrixHeight": 1024
  },
  {
    "id": "11",
    "scaleDenominator": 272531.937989174,
    "cellSize": 76.3089426369687,
    "pointOfOrigin": [-9501965.72931276,20003931.4586255],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 1024,
    "matrixHeight": 2048
  },
  {
    "id": "12",
    "scaleDenominator": 136265.968994587,
    "cellSize": 38.1544713184843,
    "pointOfOrigin": [-9501965.72931276,20003931.4586255],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 2048,
    "matrixHeight": 4096
  },
  {
    "id": "13",
    "scaleDenominator": 68132.9844972935,
    "cellSize": 19.0772356592422,
    "pointOfOrigin": [-9501965.72931276,20003931.4586255],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 4096,
    "matrixHeight": 8192
  },
  {
    "id": "14",
    "scaleDenominator": 34066.4922486467,
    "cellSize": 9.53861782962109,
    "pointOfOrigin": [-9501965.72931276,20003931.4586255],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 8192,
    "matrixHeight": 16384
  },
  {
    "id": "15",
    "scaleDenominator": 17033.2461243234,
    "cellSize": 4.76930891481054,
    "pointOfOrigin": [-9501965.72931276,20003931.4586255],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 16384,
    "matrixHeight": 32768
  },
  {
    "id": "16",
    "scaleDenominator": 8516.62306216168,
    "cellSize": 2.38465445740527,
    "pointOfOrigin": [-9501965.72931276,20003931.4586255],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 32768
  }

```

```

        "matrixHeight": 65536
    },
    {
        "id": "17",
        "scaleDenominator": 4258.31153108084,
        "cellSize": 1.19232722870264,
        "pointOfOrigin": [-9501965.72931276,20003931.4586255],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 65536,
        "matrixHeight": 131072
    },
    {
        "id": "18",
        "scaleDenominator": 2129.15576554042,
        "cellSize": 0.596163614351318,
        "pointOfOrigin": [-9501965.72931276,20003931.4586255],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 131072,
        "matrixHeight": 262144
    },
    {
        "id": "19",
        "scaleDenominator": 1064.57788277021,
        "cellSize": 0.298081807175659,
        "pointOfOrigin": [-9501965.72931276,20003931.4586255],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 262144,
        "matrixHeight": 524288
    },
    {
        "id": "20",
        "scaleDenominator": 532.288941385105,
        "cellSize": 0.149040903587829,
        "pointOfOrigin": [-9501965.72931276,20003931.4586255],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 524288,
        "matrixHeight": 1048576
    },
    {
        "id": "21",
        "scaleDenominator": 266.144470692553,
        "cellSize": 0.0745204517939147,
        "pointOfOrigin": [-9501965.72931276,20003931.4586255],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 1048576,
        "matrixHeight": 2097152
    },
    {
        "id": "22",
        "scaleDenominator": 133.072235346276,
        "cellSize": 0.0372602258969574,
        "pointOfOrigin": [-9501965.72931276,20003931.4586255],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 2097152,
        "matrixHeight": 4194304
    },

```

```

        "id": "23",
        "scaleDenominator": 66.5361176731382,
        "cellSize": 0.0186301129484787,
        "pointOfOrigin": [-9501965.72931276,20003931.4586255],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 4194304,
        "matrixHeight": 8388608
    },
    {
        "id": "24",
        "scaleDenominator": 33.2680588365691,
        "cellSize": 0.00931505647423934,
        "pointOfOrigin": [-9501965.72931276,20003931.4586255],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 8388608,
        "matrixHeight": 16777216
    }
]
}

```

F.6.2. UTM WGS84 Quad for zone 31 (XML encoding)

```

<?xml version="1.0" encoding="UTF-8"?>
<TileMatrixSet id="UTM31WGS84Quad" xmlns="http://www.opengis.net/tms/2.0"
  xmlns:tmSc="http://www.opengis.net/tms/2.0/common" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="http://www.opengis.net/tms/2.0 ../../tilematrixset.xsd">
  <tmSc:Title>Universal Transverse Mercator Zone 31 WGS84 Quad</tmSc:Title>
  <tmSc:Identifier>UTM31WGS84Quad</tmSc:Identifier>
  <uri>http://www.opengis.net/def/tilematrixset/OGC/1.0/UTM31WGS84Quad</uri>
  <tmSc:CRS>
    <tmSc:URI>http://www.opengis.net/def/crs/EPSG/0/32631</tmSc:URI>
  </tmSc:CRS>
  <OrderedAxes>E,N</OrderedAxes>
  <TileMatrix>
    <tmSc:Identifier>1</tmSc:Identifier>
    <ScaleDenominator>279072704.500914</ScaleDenominator>
    <CellSize>78140.3572602559</CellSize>
    <PointOfOrigin>-9501965.72931276 20003931.4586255</PointOfOrigin>
    <TileWidth>256</TileWidth>
    <TileHeight>256</TileHeight>
    <MatrixWidth>1</MatrixWidth>
    <MatrixHeight>2</MatrixHeight>
  </TileMatrix>
  <TileMatrix>
    <tmSc:Identifier>2</tmSc:Identifier>
    <ScaleDenominator>139536352.250457</ScaleDenominator>
    <CellSize>39070.178630128</CellSize>
    <PointOfOrigin>-9501965.72931276 20003931.4586255</PointOfOrigin>
    <TileWidth>256</TileWidth>
    <TileHeight>256</TileHeight>
    <MatrixWidth>2</MatrixWidth>
    <MatrixHeight>4</MatrixHeight>
  </TileMatrix>
  <TileMatrix>
    <tmSc:Identifier>3</tmSc:Identifier>
    <ScaleDenominator>69768176.1252285</ScaleDenominator>
    <CellSize>19535.089315064</CellSize>
    <PointOfOrigin>-9501965.72931276 20003931.4586255</PointOfOrigin>
  </TileMatrix>

```

```

<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>4</MatrixWidth>
<MatrixHeight>8</MatrixHeight>
</TileMatrix>
<TileMatrix>
    <tmsc:Identifier>4</tmsc:Identifier>
    <ScaleDenominator>34884088.0626143</ScaleDenominator>
    <CellSize>9767.5446575319</CellSize>
    <PointOfOrigin>-9501965.72931276 20003931.4586255</PointOfOrigin>
    <TileWidth>256</TileWidth>
    <TileHeight>256</TileHeight>
    <MatrixWidth>8</MatrixWidth>
    <MatrixHeight>16</MatrixHeight>
</TileMatrix>
<TileMatrix>
    <tmsc:Identifier>5</tmsc:Identifier>
    <ScaleDenominator>17442044.0313071</ScaleDenominator>
    <CellSize>4883.772328766</CellSize>
    <PointOfOrigin>-9501965.72931276 20003931.4586255</PointOfOrigin>
    <TileWidth>256</TileWidth>
    <TileHeight>256</TileHeight>
    <MatrixWidth>16</MatrixWidth>
    <MatrixHeight>32</MatrixHeight>
</TileMatrix>
<TileMatrix>
    <tmsc:Identifier>6</tmsc:Identifier>
    <ScaleDenominator>8721022.01565356</ScaleDenominator>
    <CellSize>2441.886164383</CellSize>
    <PointOfOrigin>-9501965.72931276 20003931.4586255</PointOfOrigin>
    <TileWidth>256</TileWidth>
    <TileHeight>256</TileHeight>
    <MatrixWidth>32</MatrixWidth>
    <MatrixHeight>64</MatrixHeight>
</TileMatrix>
<TileMatrix>
    <tmsc:Identifier>7</tmsc:Identifier>
    <ScaleDenominator>4360511.00782678</ScaleDenominator>
    <CellSize>1220.9430821915</CellSize>
    <PointOfOrigin>-9501965.72931276 20003931.4586255</PointOfOrigin>
    <TileWidth>256</TileWidth>
    <TileHeight>256</TileHeight>
    <MatrixWidth>64</MatrixWidth>
    <MatrixHeight>128</MatrixHeight>
</TileMatrix>
<TileMatrix>
    <tmsc:Identifier>8</tmsc:Identifier>
    <ScaleDenominator>2180255.50391339</ScaleDenominator>
    <CellSize>610.471541095749</CellSize>
    <PointOfOrigin>-9501965.72931276 20003931.4586255</PointOfOrigin>
    <TileWidth>256</TileWidth>
    <TileHeight>256</TileHeight>
    <MatrixWidth>128</MatrixWidth>
    <MatrixHeight>256</MatrixHeight>
</TileMatrix>
<TileMatrix>
    <tmsc:Identifier>9</tmsc:Identifier>
    <ScaleDenominator>1090127.7519567</ScaleDenominator>
    <CellSize>305.235770547875</CellSize>
    <PointOfOrigin>-9501965.72931276 20003931.4586255</PointOfOrigin>
    <TileWidth>256</TileWidth>
    <TileHeight>256</TileHeight>
    <MatrixWidth>256</MatrixWidth>

```

```

<MatrixHeight>512</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>10</tmsc:Identifier>
  <ScaleDenominator>545063.875978348</ScaleDenominator>
  <CellSize>152.617885273937</CellSize>
  <PointOfOrigin>-9501965.72931276 20003931.4586255</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>512</MatrixWidth>
  <MatrixHeight>1024</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>11</tmsc:Identifier>
  <ScaleDenominator>272531.937989174</ScaleDenominator>
  <CellSize>76.3089426369687</CellSize>
  <PointOfOrigin>-9501965.72931276 20003931.4586255</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>1024</MatrixWidth>
  <MatrixHeight>2048</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>12</tmsc:Identifier>
  <ScaleDenominator>136265.968994587</ScaleDenominator>
  <CellSize>38.1544713184843</CellSize>
  <PointOfOrigin>-9501965.72931276 20003931.4586255</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>2048</MatrixWidth>
  <MatrixHeight>4096</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>13</tmsc:Identifier>
  <ScaleDenominator>68132.9844972935</ScaleDenominator>
  <CellSize>19.0772356592422</CellSize>
  <PointOfOrigin>-9501965.72931276 20003931.4586255</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>4096</MatrixWidth>
  <MatrixHeight>8192</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>14</tmsc:Identifier>
  <ScaleDenominator>34066.4922486467</ScaleDenominator>
  <CellSize>9.53861782962109</CellSize>
  <PointOfOrigin>-9501965.72931276 20003931.4586255</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>8192</MatrixWidth>
  <MatrixHeight>16384</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>15</tmsc:Identifier>
  <ScaleDenominator>17033.2461243234</ScaleDenominator>
  <CellSize>4.76930891481054</CellSize>
  <PointOfOrigin>-9501965.72931276 20003931.4586255</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>16384</MatrixWidth>
  <MatrixHeight>32768</MatrixHeight>
</TileMatrix>
<TileMatrix>

```

```

<tmsc:Identifier>16</tmsc:Identifier>
<ScaleDenominator>8516.62306216168</ScaleDenominator>
<CellSize>2.38465445740527</CellSize>
<PointOfOrigin>-9501965.72931276 20003931.4586255</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>32768</MatrixWidth>
<MatrixHeight>65536</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>17</tmsc:Identifier>
<ScaleDenominator>4258.31153108084</ScaleDenominator>
<CellSize>1.19232722870264</CellSize>
<PointOfOrigin>-9501965.72931276 20003931.4586255</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>65536</MatrixWidth>
<MatrixHeight>131072</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>18</tmsc:Identifier>
<ScaleDenominator>2129.15576554042</ScaleDenominator>
<CellSize>0.596163614351318</CellSize>
<PointOfOrigin>-9501965.72931276 20003931.4586255</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>131072</MatrixWidth>
<MatrixHeight>262144</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>19</tmsc:Identifier>
<ScaleDenominator>1064.57788277021</ScaleDenominator>
<CellSize>0.298081807175659</CellSize>
<PointOfOrigin>-9501965.72931276 20003931.4586255</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>262144</MatrixWidth>
<MatrixHeight>524288</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>20</tmsc:Identifier>
<ScaleDenominator>532.288941385105</ScaleDenominator>
<CellSize>0.149040903587829</CellSize>
<PointOfOrigin>-9501965.72931276 20003931.4586255</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>524288</MatrixWidth>
<MatrixHeight>1048576</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>21</tmsc:Identifier>
<ScaleDenominator>266.144470692553</ScaleDenominator>
<CellSize>0.0745204517939147</CellSize>
<PointOfOrigin>-9501965.72931276 20003931.4586255</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>1048576</MatrixWidth>
<MatrixHeight>2097152</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>22</tmsc:Identifier>
<ScaleDenominator>133.072235346276</ScaleDenominator>
<CellSize>0.0372602258969574</CellSize>

```

```

<PointOfOrigin>-9501965.72931276 20003931.4586255</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>2097152</MatrixWidth>
<MatrixHeight>4194304</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>23</tmsc:Identifier>
<ScaleDenominator>66.5361176731382</ScaleDenominator>
<CellSize>0.0186301129484787</CellSize>
<PointOfOrigin>-9501965.72931276 20003931.4586255</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>4194304</MatrixWidth>
<MatrixHeight>8388608</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>24</tmsc:Identifier>
<ScaleDenominator>33.2680588365691</ScaleDenominator>
<CellSize>0.00931505647423934</CellSize>
<PointOfOrigin>-9501965.72931276 20003931.4586255</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>8388608</MatrixWidth>
<MatrixHeight>16777216</MatrixHeight>
</TileMatrix>
</TileMatrixSet>

```

F.7. Arctic Universal Polar Stereographic WGS 84 Quad

These are the JSON and XML definitions of the UPSArcticWGS84Quad tile matrix set (see Annex D.5) that can be reproduced by other standards needing to define a tile matrix set. Not all TileMatrix elements need to be included and including other TileMatrices for more detailed scales is possible if they follow the same pattern.

F.7.1. Arctic UPS WGS 84 Quad (JSON encoding)

```
{
  "id": "UPSArcicWGS84Quad",
  "title": "Universal Polar Stereographic WGS 84 Quad for Arctic",
  "uri": "http://www.opengis.net/def/tilematrixset/OGC/1.0/
  UPSArcticWGS84Quad",
  "crs": "http://www.opengis.net/def/crs/EPSG/0/5041",
  "orderedAxes": ["E", "N"],
  "tileMatrices": [
    {
      "id": "0",
      "scaleDenominator": 458726544.4,
      "cellSize": 128443.4324,
      "pointOfOrigin": [-14440759.350252, 18440759.350252],
      "tileWidth": 256,
      "tileHeight": 256,
      "matrixWidth": 1,
      "matrixHeight": 1
    }
  ]
}
```

```
},
{
  "id": "1",
  "scaleDenominator": 229363272.2,
  "cellSize": 64221.71621,
  "pointOfOrigin": [-14440759.350252,18440759.350252],
  "tileWidth": 256,
  "tileHeight": 256,
  "matrixWidth": 2,
  "matrixHeight": 2
},
{
  "id": "2",
  "scaleDenominator": 114681636.1,
  "cellSize": 32110.85811,
  "pointOfOrigin": [-14440759.350252,18440759.350252],
  "tileWidth": 256,
  "tileHeight": 256,
  "matrixWidth": 4,
  "matrixHeight": 4
},
{
  "id": "3",
  "scaleDenominator": 57340818.05,
  "cellSize": 16055.42905,
  "pointOfOrigin": [-14440759.350252,18440759.350252],
  "tileWidth": 256,
  "tileHeight": 256,
  "matrixWidth": 8,
  "matrixHeight": 8
},
{
  "id": "4",
  "scaleDenominator": 28670409.02,
  "cellSize": 8027.714526,
  "pointOfOrigin": [-14440759.350252,18440759.350252],
  "tileWidth": 256,
  "tileHeight": 256,
  "matrixWidth": 16,
  "matrixHeight": 16
},
{
  "id": "5",
  "scaleDenominator": 14335204.51,
  "cellSize": 4013.857263,
  "pointOfOrigin": [-14440759.350252,18440759.350252],
  "tileWidth": 256,
  "tileHeight": 256,
  "matrixWidth": 32,
  "matrixHeight": 32
},
{
  "id": "6",
  "scaleDenominator": 7167602.256,
  "cellSize": 2006.928632,
  "pointOfOrigin": [-14440759.350252,18440759.350252],
  "tileWidth": 256,
  "tileHeight": 256,
  "matrixWidth": 64,
  "matrixHeight": 64
},
{
  "id": "7",
```

```
    "scaleDenominator": 3583801.128,
    "cellSize": 1003.464316,
    "pointOfOrigin": [-14440759.350252,18440759.350252],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 128,
    "matrixHeight": 128
},
{
    "id": "8",
    "scaleDenominator": 1791900.564,
    "cellSize": 501.7321579,
    "pointOfOrigin": [-14440759.350252,18440759.350252],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 256,
    "matrixHeight": 256
},
{
    "id": "9",
    "scaleDenominator": 895950.282,
    "cellSize": 250.866079,
    "pointOfOrigin": [-14440759.350252,18440759.350252],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 512,
    "matrixHeight": 512
},
{
    "id": "10",
    "scaleDenominator": 447975.141,
    "cellSize": 125.4330395,
    "pointOfOrigin": [-14440759.350252,18440759.350252],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 1024,
    "matrixHeight": 1024
},
{
    "id": "11",
    "scaleDenominator": 223987.5705,
    "cellSize": 62.71651974,
    "pointOfOrigin": [-14440759.350252,18440759.350252],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 2048,
    "matrixHeight": 2048
},
{
    "id": "12",
    "scaleDenominator": 111993.7852,
    "cellSize": 31.35825987,
    "pointOfOrigin": [-14440759.350252,18440759.350252],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 4096,
    "matrixHeight": 4096
},
{
    "id": "13",
    "scaleDenominator": 55996.89262,
    "cellSize": 15.67912993,
    "pointOfOrigin": [-14440759.350252,18440759.350252],
```

```

    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 8192,
    "matrixHeight": 8192
},
{
    "id": "14",
    "scaleDenominator": 27998.44631,
    "cellSize": 7.839564967,
    "pointOfOrigin": [-14440759.350252,18440759.350252],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 16384,
    "matrixHeight": 16384
},
{
    "id": "15",
    "scaleDenominator": 13999.22316,
    "cellSize": 3.919782484,
    "pointOfOrigin": [-14440759.350252,18440759.350252],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 32768,
    "matrixHeight": 32768
},
{
    "id": "16",
    "scaleDenominator": 6999.611578,
    "cellSize": 1.959891242,
    "pointOfOrigin": [-14440759.350252,18440759.350252],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 65536,
    "matrixHeight": 65536
},
{
    "id": "17",
    "scaleDenominator": 3499.805789,
    "cellSize": 0.979945621,
    "pointOfOrigin": [-14440759.350252,18440759.350252],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 131072,
    "matrixHeight": 131072
},
{
    "id": "18",
    "scaleDenominator": 1749.902894,
    "cellSize": 0.48997281,
    "pointOfOrigin": [-14440759.350252,18440759.350252],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 262144,
    "matrixHeight": 262144
},
{
    "id": "19",
    "scaleDenominator": 874.9514472,
    "cellSize": 0.244986405,
    "pointOfOrigin": [-14440759.350252,18440759.350252],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 524288,

```

```

        "matrixHeight": 524288
    },
    {
        "id": "20",
        "scaleDenominator": 437.4757236,
        "cellSize": 0.122493203,
        "pointOfOrigin": [-14440759.350252,18440759.350252],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 1048576,
        "matrixHeight": 1048576
    },
    {
        "id": "21",
        "scaleDenominator": 218.7378618,
        "cellSize": 0.061246601,
        "pointOfOrigin": [-14440759.350252,18440759.350252],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 2097152,
        "matrixHeight": 2097152
    },
    {
        "id": "22",
        "scaleDenominator": 109.3689309,
        "cellSize": 0.030623301,
        "pointOfOrigin": [-14440759.350252,18440759.350252],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 4194304,
        "matrixHeight": 4194304
    },
    {
        "id": "23",
        "scaleDenominator": 54.68446545,
        "cellSize": 0.01531165,
        "pointOfOrigin": [-14440759.350252,18440759.350252],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 8388608,
        "matrixHeight": 8388608
    },
    {
        "id": "24",
        "scaleDenominator": 27.34223273,
        "cellSize": 0.007655825,
        "pointOfOrigin": [-14440759.350252,18440759.350252],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 16777216,
        "matrixHeight": 16777216
    }
]
}

```

F.7.2. Arctic UPS WGS 84 Quad (XML encoding)

```

<?xml version="1.0" encoding="UTF-8"?>
<TileMatrixSet id="UPSArcticWGS84Quad" xmlns="http://www.opengis.net/tms/2.0"
    xmlns:tmse="http://www.opengis.net/tms/2.0/common" xmlns:xsi="http://www.w3.

```

```

org/2001/XMLSchema-instance" xsi:schemaLocation="http://www.opengis.net/tms/2.
0 ../../tilematrixset.xsd">
    <tmsc:Title>Universal Polar Stereographic WGS 84 Quad for Arctic</tmsc:
Title>
    <tmsc:Identifier>UPSArcticWGS84Quad</tmsc:Identifier>
    <uri>http://www.opengis.net/def/tilematrixset/OGC/1.0/
UPSArcticWGS84Quad</uri>
    <tmsc:CRS>
        <tmsc:URI>http://www.opengis.net/def/crs/EPSG/0/5041</tmsc:URI>
    </tmsc:CRS>
    <OrderedAxes>E,N</OrderedAxes>
    <TileMatrix>
        <tmsc:Identifier>0</tmsc:Identifier>
        <ScaleDenominator>458726544.4</ScaleDenominator>
        <CellSize>128443.4324</CellSize>
        <PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>
        <TileWidth>256</TileWidth>
        <TileHeight>256</TileHeight>
        <MatrixWidth>1</MatrixWidth>
        <MatrixHeight>1</MatrixHeight>
    </TileMatrix>
    <TileMatrix>
        <tmsc:Identifier>1</tmsc:Identifier>
        <ScaleDenominator>229363272.2</ScaleDenominator>
        <CellSize>64221.71621</CellSize>
        <PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>
        <TileWidth>256</TileWidth>
        <TileHeight>256</TileHeight>
        <MatrixWidth>2</MatrixWidth>
        <MatrixHeight>2</MatrixHeight>
    </TileMatrix>
    <TileMatrix>
        <tmsc:Identifier>2</tmsc:Identifier>
        <ScaleDenominator>114681636.1</ScaleDenominator>
        <CellSize>32110.85811</CellSize>
        <PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>
        <TileWidth>256</TileWidth>
        <TileHeight>256</TileHeight>
        <MatrixWidth>4</MatrixWidth>
        <MatrixHeight>4</MatrixHeight>
    </TileMatrix>
    <TileMatrix>
        <tmsc:Identifier>3</tmsc:Identifier>
        <ScaleDenominator>57340818.05</ScaleDenominator>
        <CellSize>16055.42905</CellSize>
        <PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>
        <TileWidth>256</TileWidth>
        <TileHeight>256</TileHeight>
        <MatrixWidth>8</MatrixWidth>
        <MatrixHeight>8</MatrixHeight>
    </TileMatrix>
    <TileMatrix>
        <tmsc:Identifier>4</tmsc:Identifier>
        <ScaleDenominator>28670409.02</ScaleDenominator>
        <CellSize>8027.714526</CellSize>
        <PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>
        <TileWidth>256</TileWidth>
        <TileHeight>256</TileHeight>
        <MatrixWidth>16</MatrixWidth>
        <MatrixHeight>16</MatrixHeight>
    </TileMatrix>
    <TileMatrix>
        <tmsc:Identifier>5</tmsc:Identifier>

```

```

<ScaleDenominator>14335204.51</ScaleDenominator>
<CellSize>4013.857263</CellSize>
<PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>32</MatrixWidth>
<MatrixHeight>32</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>6</tmsc:Identifier>
  <ScaleDenominator>7167602.256</ScaleDenominator>
  <CellSize>2006.928632</CellSize>
  <PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>64</MatrixWidth>
  <MatrixHeight>64</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>7</tmsc:Identifier>
  <ScaleDenominator>3583801.128</ScaleDenominator>
  <CellSize>1003.464316</CellSize>
  <PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>128</MatrixWidth>
  <MatrixHeight>128</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>8</tmsc:Identifier>
  <ScaleDenominator>1791900.564</ScaleDenominator>
  <CellSize>501.7321579</CellSize>
  <PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>256</MatrixWidth>
  <MatrixHeight>256</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>9</tmsc:Identifier>
  <ScaleDenominator>895950.282</ScaleDenominator>
  <CellSize>250.866079</CellSize>
  <PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>512</MatrixWidth>
  <MatrixHeight>512</MatrixHeight>
</TileMatrix>
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  <ScaleDenominator>447975.141</ScaleDenominator>
  <CellSize>125.4330395</CellSize>
  <PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>1024</MatrixWidth>
  <MatrixHeight>1024</MatrixHeight>
</TileMatrix>
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  <tmsc:Identifier>11</tmsc:Identifier>
  <ScaleDenominator>223987.5705</ScaleDenominator>
  <CellSize>62.71651974</CellSize>
  <PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>

```

```

<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>2048</MatrixWidth>
<MatrixHeight>2048</MatrixHeight>
</TileMatrix>
<TileMatrix>
    <tmsc:Identifier>12</tmsc:Identifier>
    <ScaleDenominator>111993.7852</ScaleDenominator>
    <CellSize>31.35825987</CellSize>
    <PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>
    <TileWidth>256</TileWidth>
    <TileHeight>256</TileHeight>
    <MatrixWidth>4096</MatrixWidth>
    <MatrixHeight>4096</MatrixHeight>
</TileMatrix>
<TileMatrix>
    <tmsc:Identifier>13</tmsc:Identifier>
    <ScaleDenominator>55996.89262</ScaleDenominator>
    <CellSize>15.67912993</CellSize>
    <PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>
    <TileWidth>256</TileWidth>
    <TileHeight>256</TileHeight>
    <MatrixWidth>8192</MatrixWidth>
    <MatrixHeight>8192</MatrixHeight>
</TileMatrix>
<TileMatrix>
    <tmsc:Identifier>14</tmsc:Identifier>
    <ScaleDenominator>27998.44631</ScaleDenominator>
    <CellSize>7.839564967</CellSize>
    <PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>
    <TileWidth>256</TileWidth>
    <TileHeight>256</TileHeight>
    <MatrixWidth>16384</MatrixWidth>
    <MatrixHeight>16384</MatrixHeight>
</TileMatrix>
<TileMatrix>
    <tmsc:Identifier>15</tmsc:Identifier>
    <ScaleDenominator>13999.22316</ScaleDenominator>
    <CellSize>3.919782484</CellSize>
    <PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>
    <TileWidth>256</TileWidth>
    <TileHeight>256</TileHeight>
    <MatrixWidth>32768</MatrixWidth>
    <MatrixHeight>32768</MatrixHeight>
</TileMatrix>
<TileMatrix>
    <tmsc:Identifier>16</tmsc:Identifier>
    <ScaleDenominator>6999.611578</ScaleDenominator>
    <CellSize>1.959891242</CellSize>
    <PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>
    <TileWidth>256</TileWidth>
    <TileHeight>256</TileHeight>
    <MatrixWidth>65536</MatrixWidth>
    <MatrixHeight>65536</MatrixHeight>
</TileMatrix>
<TileMatrix>
    <tmsc:Identifier>17</tmsc:Identifier>
    <ScaleDenominator>3499.805789</ScaleDenominator>
    <CellSize>0.979945621</CellSize>
    <PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>
    <TileWidth>256</TileWidth>
    <TileHeight>256</TileHeight>
    <MatrixWidth>131072</MatrixWidth>

```

```

<MatrixHeight>131072</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>18</tmsc:Identifier>
  <ScaleDenominator>1749.902894</ScaleDenominator>
  <CellSize>0.48997281</CellSize>
  <PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>262144</MatrixWidth>
  <MatrixHeight>262144</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>19</tmsc:Identifier>
  <ScaleDenominator>874.9514472</ScaleDenominator>
  <CellSize>0.244986405</CellSize>
  <PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>524288</MatrixWidth>
  <MatrixHeight>524288</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>20</tmsc:Identifier>
  <ScaleDenominator>437.4757236</ScaleDenominator>
  <CellSize>0.122493203</CellSize>
  <PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>1048576</MatrixWidth>
  <MatrixHeight>1048576</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>21</tmsc:Identifier>
  <ScaleDenominator>218.7378618</ScaleDenominator>
  <CellSize>0.061246601</CellSize>
  <PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>2097152</MatrixWidth>
  <MatrixHeight>2097152</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>22</tmsc:Identifier>
  <ScaleDenominator>109.3689309</ScaleDenominator>
  <CellSize>0.030623301</CellSize>
  <PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>4194304</MatrixWidth>
  <MatrixHeight>4194304</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>23</tmsc:Identifier>
  <ScaleDenominator>54.68446545</ScaleDenominator>
  <CellSize>0.01531165</CellSize>
  <PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>8388608</MatrixWidth>
  <MatrixHeight>8388608</MatrixHeight>
</TileMatrix>
<TileMatrix>

```

```

<tmsc:Identifier>24</tmsc:Identifier>
<ScaleDenominator>27.34223273</ScaleDenominator>
<CellSize>0.007655825</CellSize>
<PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>16777216</MatrixWidth>
<MatrixHeight>16777216</MatrixHeight>
</TileMatrix>
</TileMatrixSet>

```

F.8. Antarctic Universal Polar Stereographic WGS84 Quad

These are the JSON and XML definitions of the UPSAntarcticWGS84Quad tile matrix set (see Annex D.6) that can be reproduced by other standards needing to define a tile matrix set. Not all TileMatrix elements need to be included and including other TileMatrices for more detailed scales is possible if they follow the same pattern.

F.8.1. Antarctic UPS WGS84 Quad (JSON encoding)

```
{
  "id": "UPSAntarcticWGS84Quad",
  "title": "Universal Polar Stereographic WGS 84 Quad for Antarctic",
  "uri": "http://www.opengis.net/def/tilematrixset/OGC/1.0/
  UPSAntarcticWGS84Quad",
  "crs": "http://www.opengis.net/def/crs/EPSG/0/5042",
  "orderedAxes": ["E", "N"],
  "tileMatrices": [
    {
      "id": "0",
      "scaleDenominator": 458726544.4,
      "cellSize": 128443.4324,
      "pointOfOrigin": [-14440759.350252, 18440759.350252],
      "tileWidth": 256,
      "tileHeight": 256,
      "matrixWidth": 1,
      "matrixHeight": 1
    },
    {
      "id": "1",
      "scaleDenominator": 229363272.2,
      "cellSize": 64221.71621,
      "pointOfOrigin": [-14440759.350252, 18440759.350252],
      "tileWidth": 256,
      "tileHeight": 256,
      "matrixWidth": 2,
      "matrixHeight": 2
    },
    {
      "id": "2",
      "scaleDenominator": 114681636.1,
      "cellSize": 32110.85811,
      "pointOfOrigin": [-14440759.350252, 18440759.350252],
      "tileWidth": 256,
    }
  ]
}
```

```

    "tileHeight": 256,
    "matrixWidth": 4,
    "matrixHeight": 4
  },
  {
    "id": "3",
    "scaleDenominator": 57340818.05,
    "cellSize": 16055.42905,
    "pointOfOrigin": [-14440759.350252,18440759.350252],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 8,
    "matrixHeight": 8
  },
  {
    "id": "4",
    "scaleDenominator": 28670409.02,
    "cellSize": 8027.714526,
    "pointOfOrigin": [-14440759.350252,18440759.350252],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 16,
    "matrixHeight": 16
  },
  {
    "id": "5",
    "scaleDenominator": 14335204.51,
    "cellSize": 4013.857263,
    "pointOfOrigin": [-14440759.350252,18440759.350252],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 32,
    "matrixHeight": 32
  },
  {
    "id": "6",
    "scaleDenominator": 7167602.256,
    "cellSize": 2006.928632,
    "pointOfOrigin": [-14440759.350252,18440759.350252],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 64,
    "matrixHeight": 64
  },
  {
    "id": "7",
    "scaleDenominator": 3583801.128,
    "cellSize": 1003.464316,
    "pointOfOrigin": [-14440759.350252,18440759.350252],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 128,
    "matrixHeight": 128
  },
  {
    "id": "8",
    "scaleDenominator": 1791900.564,
    "cellSize": 501.7321579,
    "pointOfOrigin": [-14440759.350252,18440759.350252],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 256,
    "matrixHeight": 256
  }

```

```
},
{
  "id": "9",
  "scaleDenominator": 895950.282,
  "cellSize": 250.866079,
  "pointOfOrigin": [-14440759.350252,18440759.350252],
  "tileWidth": 256,
  "tileHeight": 256,
  "matrixWidth": 512,
  "matrixHeight": 512
},
{
  "id": "10",
  "scaleDenominator": 447975.141,
  "cellSize": 125.4330395,
  "pointOfOrigin": [-14440759.350252,18440759.350252],
  "tileWidth": 256,
  "tileHeight": 256,
  "matrixWidth": 1024,
  "matrixHeight": 1024
},
{
  "id": "11",
  "scaleDenominator": 223987.5705,
  "cellSize": 62.71651974,
  "pointOfOrigin": [-14440759.350252,18440759.350252],
  "tileWidth": 256,
  "tileHeight": 256,
  "matrixWidth": 2048,
  "matrixHeight": 2048
},
{
  "id": "12",
  "scaleDenominator": 111993.7852,
  "cellSize": 31.35825987,
  "pointOfOrigin": [-14440759.350252,18440759.350252],
  "tileWidth": 256,
  "tileHeight": 256,
  "matrixWidth": 4096,
  "matrixHeight": 4096
},
{
  "id": "13",
  "scaleDenominator": 55996.89262,
  "cellSize": 15.67912993,
  "pointOfOrigin": [-14440759.350252,18440759.350252],
  "tileWidth": 256,
  "tileHeight": 256,
  "matrixWidth": 8192,
  "matrixHeight": 8192
},
{
  "id": "14",
  "scaleDenominator": 27998.44631,
  "cellSize": 7.839564967,
  "pointOfOrigin": [-14440759.350252,18440759.350252],
  "tileWidth": 256,
  "tileHeight": 256,
  "matrixWidth": 16384,
  "matrixHeight": 16384
},
{
  "id": "15",
```

```
        "scaleDenominator": 13999.22316,
        "cellSize": 3.919782484,
        "pointOfOrigin": [-14440759.350252,18440759.350252],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 32768,
        "matrixHeight": 32768
    },
    {
        "id": "16",
        "scaleDenominator": 6999.611578,
        "cellSize": 1.959891242,
        "pointOfOrigin": [-14440759.350252,18440759.350252],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 65536,
        "matrixHeight": 65536
    },
    {
        "id": "17",
        "scaleDenominator": 3499.805789,
        "cellSize": 0.979945621,
        "pointOfOrigin": [-14440759.350252,18440759.350252],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 131072,
        "matrixHeight": 131072
    },
    {
        "id": "18",
        "scaleDenominator": 1749.902894,
        "cellSize": 0.48997281,
        "pointOfOrigin": [-14440759.350252,18440759.350252],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 262144,
        "matrixHeight": 262144
    },
    {
        "id": "19",
        "scaleDenominator": 874.9514472,
        "cellSize": 0.244986405,
        "pointOfOrigin": [-14440759.350252,18440759.350252],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 524288,
        "matrixHeight": 524288
    },
    {
        "id": "20",
        "scaleDenominator": 437.4757236,
        "cellSize": 0.122493203,
        "pointOfOrigin": [-14440759.350252,18440759.350252],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 1048576,
        "matrixHeight": 1048576
    },
    {
        "id": "21",
        "scaleDenominator": 218.7378618,
        "cellSize": 0.061246601,
        "pointOfOrigin": [-14440759.350252,18440759.350252],
```

```

        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 2097152,
        "matrixHeight": 2097152
    },
    {
        "id": "22",
        "scaleDenominator": 109.3689309,
        "cellSize": 0.030623301,
        "pointOfOrigin": [-14440759.350252,18440759.350252],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 4194304,
        "matrixHeight": 4194304
    },
    {
        "id": "23",
        "scaleDenominator": 54.68446545,
        "cellSize": 0.01531165,
        "pointOfOrigin": [-14440759.350252,18440759.350252],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 8388608,
        "matrixHeight": 8388608
    },
    {
        "id": "24",
        "scaleDenominator": 27.34223273,
        "cellSize": 0.007655825,
        "pointOfOrigin": [-14440759.350252,18440759.350252],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 16777216,
        "matrixHeight": 16777216
    }
]
}

```

F.8.2. Antarctic UPS WGS84 Quad (XML encoding)

```

<?xml version="1.0" encoding="UTF-8"?>
<TileMatrixSet id="UPSAntarcticWGS84Quad" xmlns="http://www.opengis.net/tms/2.0" xmlns:tmSc="http://www.opengis.net/tms/2.0/common" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="http://www.opengis.net/tms/2.0 ../../tilematrixset.xsd">
    <tmSc:Title>Universal Polar Stereographic WGS 84 Quad for Antarctic</tmSc:Title>
    <tmSc:Identifier>UPSAntarcticWGS84Quad</tmSc:Identifier>
    <uri>http://www.opengis.net/def/tilematrixset/OGC/1.0/UPSAntarcticWGS84Quad</uri>
    <tmSc:CRS>
        <tmSc:URI>http://www.opengis.net/def/crs/EPSG/0/5042</tmSc:URI>
    </tmSc:CRS>
    <OrderedAxes>E,N</OrderedAxes>
    <TileMatrix>
        <tmSc:Identifier>0</tmSc:Identifier>
        <ScaleDenominator>458726544.4</ScaleDenominator>
        <CellSize>128443.4324</CellSize>
        <PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>
        <TileWidth>256</TileWidth>
        <TileHeight>256</TileHeight>
    
```

```

<MatrixWidth>1</MatrixWidth>
<MatrixHeight>1</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>1</tmsc:Identifier>
<ScaleDenominator>229363272.2</ScaleDenominator>
<CellSize>64221.71621</CellSize>
<PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>2</MatrixWidth>
<MatrixHeight>2</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>2</tmsc:Identifier>
<ScaleDenominator>114681636.1</ScaleDenominator>
<CellSize>32110.85811</CellSize>
<PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>4</MatrixWidth>
<MatrixHeight>4</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>3</tmsc:Identifier>
<ScaleDenominator>57340818.05</ScaleDenominator>
<CellSize>16055.42905</CellSize>
<PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>8</MatrixWidth>
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</TileMatrix>
<TileMatrix>
<tmsc:Identifier>4</tmsc:Identifier>
<ScaleDenominator>28670409.02</ScaleDenominator>
<CellSize>8027.714526</CellSize>
<PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>16</MatrixWidth>
<MatrixHeight>16</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>5</tmsc:Identifier>
<ScaleDenominator>14335204.51</ScaleDenominator>
<CellSize>4013.857263</CellSize>
<PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>32</MatrixWidth>
<MatrixHeight>32</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>6</tmsc:Identifier>
<ScaleDenominator>7167602.256</ScaleDenominator>
<CellSize>2006.928632</CellSize>
<PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>64</MatrixWidth>
<MatrixHeight>64</MatrixHeight>
</TileMatrix>

```

```

<TileMatrix>
  <tmsc:Identifier>7</tmsc:Identifier>
  <ScaleDenominator>3583801.128</ScaleDenominator>
  <CellSize>1003.464316</CellSize>
  <PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>128</MatrixWidth>
  <MatrixHeight>128</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>8</tmsc:Identifier>
  <ScaleDenominator>1791900.564</ScaleDenominator>
  <CellSize>501.7321579</CellSize>
  <PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>256</MatrixWidth>
  <MatrixHeight>256</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>9</tmsc:Identifier>
  <ScaleDenominator>895950.282</ScaleDenominator>
  <CellSize>250.866079</CellSize>
  <PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>512</MatrixWidth>
  <MatrixHeight>512</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>10</tmsc:Identifier>
  <ScaleDenominator>447975.141</ScaleDenominator>
  <CellSize>125.4330395</CellSize>
  <PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>1024</MatrixWidth>
  <MatrixHeight>1024</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>11</tmsc:Identifier>
  <ScaleDenominator>223987.5705</ScaleDenominator>
  <CellSize>62.71651974</CellSize>
  <PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>2048</MatrixWidth>
  <MatrixHeight>2048</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>12</tmsc:Identifier>
  <ScaleDenominator>111993.7852</ScaleDenominator>
  <CellSize>31.35825987</CellSize>
  <PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>4096</MatrixWidth>
  <MatrixHeight>4096</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>13</tmsc:Identifier>
  <ScaleDenominator>55996.89262</ScaleDenominator>

```

```

<CellSize>15.67912993</CellSize>
<PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>8192</MatrixWidth>
<MatrixHeight>8192</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>14</tmsc:Identifier>
<ScaleDenominator>27998.44631</ScaleDenominator>
<CellSize>7.839564967</CellSize>
<PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>16384</MatrixWidth>
<MatrixHeight>16384</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>15</tmsc:Identifier>
<ScaleDenominator>13999.22316</ScaleDenominator>
<CellSize>3.919782484</CellSize>
<PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>32768</MatrixWidth>
<MatrixHeight>32768</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>16</tmsc:Identifier>
<ScaleDenominator>6999.611578</ScaleDenominator>
<CellSize>1.959891242</CellSize>
<PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>65536</MatrixWidth>
<MatrixHeight>65536</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>17</tmsc:Identifier>
<ScaleDenominator>3499.805789</ScaleDenominator>
<CellSize>0.979945621</CellSize>
<PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>131072</MatrixWidth>
<MatrixHeight>131072</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>18</tmsc:Identifier>
<ScaleDenominator>1749.902894</ScaleDenominator>
<CellSize>0.48997281</CellSize>
<PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>262144</MatrixWidth>
<MatrixHeight>262144</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>19</tmsc:Identifier>
<ScaleDenominator>874.9514472</ScaleDenominator>
<CellSize>0.244986405</CellSize>
<PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>
<TileWidth>256</TileWidth>

```

```

<TileHeight>256</TileHeight>
<MatrixWidth>524288</MatrixWidth>
<MatrixHeight>524288</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>20</tmsc:Identifier>
<ScaleDenominator>437.4757236</ScaleDenominator>
<CellSize>0.122493203</CellSize>
<PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>1048576</MatrixWidth>
<MatrixHeight>1048576</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>21</tmsc:Identifier>
<ScaleDenominator>218.7378618</ScaleDenominator>
<CellSize>0.061246601</CellSize>
<PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>2097152</MatrixWidth>
<MatrixHeight>2097152</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>22</tmsc:Identifier>
<ScaleDenominator>109.3689309</ScaleDenominator>
<CellSize>0.030623301</CellSize>
<PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>4194304</MatrixWidth>
<MatrixHeight>4194304</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>23</tmsc:Identifier>
<ScaleDenominator>54.68446545</ScaleDenominator>
<CellSize>0.01531165</CellSize>
<PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>8388608</MatrixWidth>
<MatrixHeight>8388608</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>24</tmsc:Identifier>
<ScaleDenominator>27.34223273</ScaleDenominator>
<CellSize>0.007655825</CellSize>
<PointOfOrigin>-14440759.350252 18440759.350252</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>16777216</MatrixWidth>
<MatrixHeight>16777216</MatrixHeight>
</TileMatrix>
</TileMatrixSet>

```

F.9. European ETRS89 Lambert Azimuthal Equal-Area Quad

These are the JSON and XML definitions of the EuropeanETRS89_LAEAQuad tile matrix set (see Annex D.7) that can be reproduced by other standards needing to define a tile matrix set. Not all TileMatrix elements need to be included and including other TileMatrices for more detailed scales is possible if they follow the same pattern.

F.9.1. European ETRS89 Lambert azimuthal equal-area Quad (JSON encoding)

```
{
  "id": "EuropeanETRS89_LAEAQuad",
  "title": "Lambert Azimuthal Equal Area ETRS89 for Europe",
  "uri": "http://www.opengis.net/def/tilematrixset/OGC/1.0/EuropeanETRS89_LAEAQuad",
  "crs": "http://www.opengis.net/def/crs/EPSG/0/3035",
  "orderedAxes": [ "Y", "X" ],
  "tileMatrices": [
    {
      {
        "id": "0",
        "scaleDenominator": 62779017.8571428,
        "cellSize": 17578.125,
        "pointOfOrigin": [5500000.0, 2000000.0],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 1,
        "matrixHeight": 1
      },
      {
        "id": "1",
        "scaleDenominator": 31389508.9285714,
        "cellSize": 8789.0625,
        "pointOfOrigin": [5500000.0, 2000000.0],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 2,
        "matrixHeight": 2
      },
      {
        "id": "2",
        "scaleDenominator": 15694754.4642857,
        "cellSize": 4394.53125,
        "pointOfOrigin": [5500000.0, 2000000.0],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 4,
        "matrixHeight": 4
      },
      {
        "id": "3",
        "scaleDenominator": 7847377.23214285,
        "cellSize": 2197.265625,
        "matrixWidth": 8,
        "matrixHeight": 8
      }
    ]
  ]
}
```

```

    "pointOfOrigin": [5500000.0, 2000000.0],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 8,
    "matrixHeight": 8
  },
  {
    "id": "4",
    "scaleDenominator": 3923688.61607142,
    "cellSize": 1098.6328125,
    "pointOfOrigin": [5500000.0, 2000000.0],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 16,
    "matrixHeight": 16
  },
  {
    "id": "5",
    "scaleDenominator": 1961844.30803571,
    "cellSize": 549.31640625,
    "pointOfOrigin": [5500000.0, 2000000.0],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 32,
    "matrixHeight": 32
  },
  {
    "id": "6",
    "scaleDenominator": 980922.154017857,
    "cellSize": 274.658203125,
    "pointOfOrigin": [5500000.0, 2000000.0],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 64,
    "matrixHeight": 64
  },
  {
    "id": "7",
    "scaleDenominator": 490461.077008928,
    "cellSize": 137.3291015625,
    "pointOfOrigin": [5500000.0, 2000000.0],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 128,
    "matrixHeight": 128
  },
  {
    "id": "8",
    "scaleDenominator": 245230.538504464,
    "cellSize": 68.6645507812,
    "pointOfOrigin": [5500000.0, 2000000.0],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 256,
    "matrixHeight": 256
  },
  {
    "id": "9",
    "scaleDenominator": 122615.269252232,
    "cellSize": 34.3322753906,
    "pointOfOrigin": [5500000.0, 2000000.0],
    "tileWidth": 256,
    "tileHeight": 256,

```

```

    "matrixWidth": 512,
    "matrixHeight": 512
},
{
    "id": "10",
    "scaleDenominator": 61307.634626116,
    "cellSize": 17.1661376953,
    "pointOfOrigin": [5500000.0, 2000000.0],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 1024,
    "matrixHeight": 1024
},
{
    "id": "11",
    "scaleDenominator": 30653.817313058,
    "cellSize": 8.5830688477,
    "pointOfOrigin": [5500000.0, 2000000.0],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 2048,
    "matrixHeight": 2048
},
{
    "id": "12",
    "scaleDenominator": 15326.908656529,
    "cellSize": 4.2915344238,
    "pointOfOrigin": [5500000.0, 2000000.0],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 4096,
    "matrixHeight": 4096
},
{
    "id": "13",
    "scaleDenominator": 7663.45432826451,
    "cellSize": 2.1457672119,
    "pointOfOrigin": [5500000.0, 2000000.0],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 8192,
    "matrixHeight": 8192
},
{
    "id": "14",
    "scaleDenominator": 3831.72716413225,
    "cellSize": 1.072883606,
    "pointOfOrigin": [5500000.0, 2000000.0],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 16384,
    "matrixHeight": 16384
},
{
    "id": "15",
    "scaleDenominator": 1915.86358206612,
    "cellSize": 0.536441803,
    "pointOfOrigin": [5500000.0, 2000000.0],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 32768,
    "matrixHeight": 32768
}

```

```
    ]  
}
```

F.9.2. European ETRS89 Lambert Azimuthal Equal-Area Quad (XML encoding)

```
<?xml version="1.0" encoding="UTF-8"?>  
<TileMatrixSet id="EuropeanETRS89_LAEAQuad" xmlns="http://www.opengis.net/tms/2.0" xmlns:tmsc="http://www.opengis.net/tms/2.0/common" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="http://www.opengis.net/tms/2.0 ../../tilematrixset.xsd">  
    <tmsc:Title>Lambert Azimuthal Equal Area ETRS89 for Europe</tmsc:Title>  
    <tmsc:Identifier>EuropeanETRS89_LAEAQuad</tmsc:Identifier>  
    <uri>http://www.opengis.net/def/tilematrixset/OGC/1.0/EuropeanETRS89_LAEAQuad</uri>  
    <tmsc:CRS>  
        <tmsc:URI>http://www.opengis.net/def/crs/EPSG/0/3035</tmsc:URI>  
    </tmsc:CRS>  
    <OrderedAxes>Y,X</OrderedAxes>  
    <TileMatrix>  
        <tmsc:Identifier>0</tmsc:Identifier>  
        <ScaleDenominator>62779017.8571428</ScaleDenominator>  
        <CellSize>17578.125</CellSize>  
        <PointOfOrigin>5500000.0 2000000.0</PointOfOrigin>  
        <TileWidth>256</TileWidth>  
        <TileHeight>256</TileHeight>  
        <MatrixWidth>1</MatrixWidth>  
        <MatrixHeight>1</MatrixHeight>  
    </TileMatrix>  
    <TileMatrix>  
        <tmsc:Identifier>1</tmsc:Identifier>  
        <ScaleDenominator>31389508.9285714</ScaleDenominator>  
        <CellSize>8789.0625</CellSize>  
        <PointOfOrigin>5500000.0 2000000.0</PointOfOrigin>  
        <TileWidth>256</TileWidth>  
        <TileHeight>256</TileHeight>  
        <MatrixWidth>2</MatrixWidth>  
        <MatrixHeight>2</MatrixHeight>  
    </TileMatrix>  
    <TileMatrix>  
        <tmsc:Identifier>2</tmsc:Identifier>  
        <ScaleDenominator>15694754.4642857</ScaleDenominator>  
        <CellSize>4394.53125</CellSize>  
        <PointOfOrigin>5500000.0 2000000.0</PointOfOrigin>  
        <TileWidth>256</TileWidth>  
        <TileHeight>256</TileHeight>  
        <MatrixWidth>4</MatrixWidth>  
        <MatrixHeight>4</MatrixHeight>  
    </TileMatrix>  
    <TileMatrix>  
        <tmsc:Identifier>3</tmsc:Identifier>  
        <ScaleDenominator>7847377.23214285</ScaleDenominator>  
        <CellSize>2197.265625</CellSize>  
        <PointOfOrigin>5500000.0 2000000.0</PointOfOrigin>  
        <TileWidth>256</TileWidth>  
        <TileHeight>256</TileHeight>  
        <MatrixWidth>8</MatrixWidth>  
        <MatrixHeight>8</MatrixHeight>  
    </TileMatrix>  
    <TileMatrix>  
        <tmsc:Identifier>4</tmsc:Identifier>
```

```

<ScaleDenominator>3923688.61607142</ScaleDenominator>
<CellSize>1098.6328125</CellSize>
<PointOfOrigin>5500000.0 2000000.0</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>16</MatrixWidth>
<MatrixHeight>16</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>5</tmsc:Identifier>
<ScaleDenominator>1961844.30803571</ScaleDenominator>
<CellSize>549.31640625</CellSize>
<PointOfOrigin>5500000.0 2000000.0</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>32</MatrixWidth>
<MatrixHeight>32</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>6</tmsc:Identifier>
<ScaleDenominator>980922.154017857</ScaleDenominator>
<CellSize>274.658203125</CellSize>
<PointOfOrigin>5500000.0 2000000.0</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>64</MatrixWidth>
<MatrixHeight>64</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>7</tmsc:Identifier>
<ScaleDenominator>490461.077008928</ScaleDenominator>
<CellSize>137.3291015625</CellSize>
<PointOfOrigin>5500000.0 2000000.0</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>128</MatrixWidth>
<MatrixHeight>128</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>8</tmsc:Identifier>
<ScaleDenominator>245230.538504464</ScaleDenominator>
<CellSize>68.6645507812</CellSize>
<PointOfOrigin>5500000.0 2000000.0</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>256</MatrixWidth>
<MatrixHeight>256</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>9</tmsc:Identifier>
<ScaleDenominator>122615.269252232</ScaleDenominator>
<CellSize>34.3322753906</CellSize>
<PointOfOrigin>5500000.0 2000000.0</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>512</MatrixWidth>
<MatrixHeight>512</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>10</tmsc:Identifier>
<ScaleDenominator>61307.634626116</ScaleDenominator>
<CellSize>17.1661376953</CellSize>
<PointOfOrigin>5500000.0 2000000.0</PointOfOrigin>

```

```

<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>1024</MatrixWidth>
<MatrixHeight>1024</MatrixHeight>
</TileMatrix>
<TileMatrix>
    <tmsc:Identifier>11</tmsc:Identifier>
    <ScaleDenominator>30653.817313058</ScaleDenominator>
    <CellSize>8.5830688477</CellSize>
    <PointOfOrigin>5500000.0 2000000.0</PointOfOrigin>
    <TileWidth>256</TileWidth>
    <TileHeight>256</TileHeight>
    <MatrixWidth>2048</MatrixWidth>
    <MatrixHeight>2048</MatrixHeight>
</TileMatrix>
<TileMatrix>
    <tmsc:Identifier>12</tmsc:Identifier>
    <ScaleDenominator>15326.908656529</ScaleDenominator>
    <CellSize>4.2915344238</CellSize>
    <PointOfOrigin>5500000.0 2000000.0</PointOfOrigin>
    <TileWidth>256</TileWidth>
    <TileHeight>256</TileHeight>
    <MatrixWidth>4096</MatrixWidth>
    <MatrixHeight>4096</MatrixHeight>
</TileMatrix>
<TileMatrix>
    <tmsc:Identifier>13</tmsc:Identifier>
    <ScaleDenominator>7663.45432826451</ScaleDenominator>
    <CellSize>2.1457672119</CellSize>
    <PointOfOrigin>5500000.0 2000000.0</PointOfOrigin>
    <TileWidth>256</TileWidth>
    <TileHeight>256</TileHeight>
    <MatrixWidth>8192</MatrixWidth>
    <MatrixHeight>8192</MatrixHeight>
</TileMatrix>
<TileMatrix>
    <tmsc:Identifier>14</tmsc:Identifier>
    <ScaleDenominator>3831.72716413225</ScaleDenominator>
    <CellSize>1.072883606</CellSize>
    <PointOfOrigin>5500000.0 2000000.0</PointOfOrigin>
    <TileWidth>256</TileWidth>
    <TileHeight>256</TileHeight>
    <MatrixWidth>16384</MatrixWidth>
    <MatrixHeight>16384</MatrixHeight>
</TileMatrix>
<TileMatrix>
    <tmsc:Identifier>15</tmsc:Identifier>
    <ScaleDenominator>1915.86358206612</ScaleDenominator>
    <CellSize>0.536441803</CellSize>
    <PointOfOrigin>5500000.0 2000000.0</PointOfOrigin>
    <TileWidth>256</TileWidth>
    <TileHeight>256</TileHeight>
    <MatrixWidth>32768</MatrixWidth>
    <MatrixHeight>32768</MatrixHeight>
</TileMatrix>
</TileMatrixSet>

```

F.10. Canadian Lambert Conformal Conic NAD83

These are the JSON and XML definitions of the CanadianNAD83_LCC tile matrix set (see Annex D.8) that can be reproduced by other standards needing to define a tile matrix set. Not all TileMatrix elements need to be included and including other TileMatrices for more detailed scales is possible if they follow the same pattern.

F.10.1. Canadian Lambert Conformal Conic NAD83 (JSON encoding)

```
{
  "id": "CanadianNAD83_LCC",
  "title": "Lambert conformal conic NAD83 for Canada",
  "uri": "http://www.opengis.net/def/tilematrixset/OGC/1.0/CanadianNAD83_LCC",
  "crs": "http://www.opengis.net/def/crs/EPSG/0/3978",
  "orderedAxes": ["E", "N"],
  "tileMatrices": [
    {
      "id": "0",
      "scaleDenominator": 145000000,
      "cellSize": 38364.6600626534,
      "pointOfOrigin": [-34655800,39310000],
      "tileWidth": 256,
      "tileHeight": 256,
      "matrixWidth": 5,
      "matrixHeight": 5
    },
    {
      "id": "1",
      "scaleDenominator": 85000000,
      "cellSize": 22489.6283125899,
      "pointOfOrigin": [-34655800,39310000],
      "tileWidth": 256,
      "tileHeight": 256,
      "matrixWidth": 8,
      "matrixHeight": 8
    },
    {
      "id": "2",
      "scaleDenominator": 50000000,
      "cellSize": 13229.1931250529,
      "pointOfOrigin": [-34655800,39310000],
      "tileWidth": 256,
      "tileHeight": 256,
      "matrixWidth": 13,
      "matrixHeight": 14
    },
    {
      "id": "3",
      "scaleDenominator": 30000000,
      "cellSize": 7937.51587503175,
      "pointOfOrigin": [-34655800,39310000],
      "tileWidth": 256,
      "tileHeight": 256,
      "matrixWidth": 21,
      "matrixHeight": 22
    }
  ]
}
```

```
},
{
  "id": "4",
  "scaleDenominator": 17500000,
  "cellSize": 4630.21759376852,
  "pointOfOrigin": [-34655800,39310000],
  "tileWidth": 256,
  "tileHeight": 256,
  "matrixWidth": 36,
  "matrixHeight": 38
},
{
  "id": "5",
  "scaleDenominator": 10000000,
  "cellSize": 2645.83862501058,
  "pointOfOrigin": [-34655800,39310000],
  "tileWidth": 256,
  "tileHeight": 256,
  "matrixWidth": 62,
  "matrixHeight": 66
},
{
  "id": "6",
  "scaleDenominator": 6000000,
  "cellSize": 1587.50317500635,
  "pointOfOrigin": [-34655800,39310000],
  "tileWidth": 256,
  "tileHeight": 256,
  "matrixWidth": 103,
  "matrixHeight": 110
},
{
  "id": "7",
  "scaleDenominator": 3500000,
  "cellSize": 926.043518753704,
  "pointOfOrigin": [-34655800,39310000],
  "tileWidth": 256,
  "tileHeight": 256,
  "matrixWidth": 177,
  "matrixHeight": 188
},
{
  "id": "8",
  "scaleDenominator": 2000000,
  "cellSize": 529.167725002116,
  "pointOfOrigin": [-34655800,39310000],
  "tileWidth": 256,
  "tileHeight": 256,
  "matrixWidth": 309,
  "matrixHeight": 329
},
{
  "id": "9",
  "scaleDenominator": 1200000,
  "cellSize": 317.50063500127,
  "pointOfOrigin": [-34655800,39310000],
  "tileWidth": 256,
  "tileHeight": 256,
  "matrixWidth": 515,
  "matrixHeight": 548
},
{
  "id": "10",
```

```

    "scaleDenominator": 700000,
    "cellSize": 185.20870375074,
    "pointOfOrigin": [-34655800,39310000],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 882,
    "matrixHeight": 938
},
{
    "id": "11",
    "scaleDenominator": 420000,
    "cellSize": 111.125222250444,
    "pointOfOrigin": [-34655800,39310000],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 1470,
    "matrixHeight": 1563
},
{
    "id": "12",
    "scaleDenominator": 250000,
    "cellSize": 66.1459656252646,
    "pointOfOrigin": [-34655800,39310000],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 2469,
    "matrixHeight": 2626
},
{
    "id": "13",
    "scaleDenominator": 145000,
    "cellSize": 38.3646600626534,
    "pointOfOrigin": [-34655800,39310000],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 4257,
    "matrixHeight": 4528
},
{
    "id": "14",
    "scaleDenominator": 85000,
    "cellSize": 22.4896283125899,
    "pointOfOrigin": [-34655800,39310000],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 7262,
    "matrixHeight": 7723
},
{
    "id": "15",
    "scaleDenominator": 50000,
    "cellSize": 13.2291931250529,
    "pointOfOrigin": [-34655800,39310000],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 12344,
    "matrixHeight": 13130
},
{
    "id": "16",
    "scaleDenominator": 30000,
    "cellSize": 7.93751587503175,
    "pointOfOrigin": [-34655800,39310000],

```

```

    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 20574,
    "matrixHeight": 21882
},
{
    "id": "17",
    "scaleDenominator": 17500,
    "cellSize": 4.63021759376852,
    "pointOfOrigin": [-34655800,39310000],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 35269,
    "matrixHeight": 37512
},
{
    "id": "18",
    "scaleDenominator": 10000,
    "cellSize": 2.64583862501058,
    "pointOfOrigin": [-34655800,39310000],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 61720,
    "matrixHeight": 65646
},
{
    "id": "19",
    "scaleDenominator": 6000,
    "cellSize": 1.58750317500635,
    "pointOfOrigin": [-34655800,39310000],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 102866,
    "matrixHeight": 109409
},
{
    "id": "20",
    "scaleDenominator": 3500,
    "cellSize": 0.926043518753704,
    "pointOfOrigin": [-34655800,39310000],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 176341,
    "matrixHeight": 187558
},
{
    "id": "21",
    "scaleDenominator": 2000,
    "cellSize": 0.529167725002116,
    "pointOfOrigin": [-34655800,39310000],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 308596,
    "matrixHeight": 328227
},
{
    "id": "22",
    "scaleDenominator": 1200,
    "cellSize": 0.31750063500127,
    "pointOfOrigin": [-34655800,39310000],
    "tileWidth": 256,
    "tileHeight": 256,
    "matrixWidth": 514327,

```

```

        "matrixHeight": 547044
    },
    {
        "id": "23",
        "scaleDenominator": 700,
        "cellSize": 0.18520870375074,
        "pointOfOrigin": [-34655800,39310000],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 881703,
        "matrixHeight": 937790
    },
    {
        "id": "24",
        "scaleDenominator": 420,
        "cellSize": 0.111125222250444,
        "pointOfOrigin": [-34655800,39310000],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 1469505,
        "matrixHeight": 1562983
    },
    {
        "id": "25",
        "scaleDenominator": 250,
        "cellSize": 0.0661459656252645,
        "pointOfOrigin": [-34655800,39310000],
        "tileWidth": 256,
        "tileHeight": 256,
        "matrixWidth": 2468768,
        "matrixHeight": 2625811
    }
]
}

```

F.10.2. Canadian Lambert Conformal Conic NAD83 (XML encoding)

```

<?xml version="1.0" encoding="UTF-8"?>
<TileMatrixSet id="CanadianNAD83_LCC" xmlns="http://www.opengis.net/tms/2.0"
  xmlns:tmsc="http://www.opengis.net/tms/2.0/common" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="http://www.opengis.net/tms/2.0 ../../tilematrixset.xsd">
  <tmsc:Title>Lambert Conformal Conic NAD83 for Canada</tmsc:Title>
  <tmsc:Identifier>CanadianNAD83_LCC</tmsc:Identifier>
    <uri>http://www.opengis.net/def/tilematrixset/OGC/1.0/CanadianNAD83_LCC</uri>
  <tmsc:CRS>
    <tmsc:URI>http://www.opengis.net/def/crs/EPSG/0/3978</tmsc:URI>
  </tmsc:CRS>
    <OrderedAxes>E,N</OrderedAxes>
  <TileMatrix>
    <tmsc:Identifier>0</tmsc:Identifier>
    <ScaleDenominator>145000000</ScaleDenominator>
    <CellSize>38364.6600626534</CellSize>
    <PointOfOrigin>-34655800 39310000</PointOfOrigin>
    <TileWidth>256</TileWidth>
    <TileHeight>256</TileHeight>
    <MatrixWidth>5</MatrixWidth>
    <MatrixHeight>5</MatrixHeight>
  </TileMatrix>
</TileMatrix>

```

```

<tmsc:Identifier>1</tmsc:Identifier>
<ScaleDenominator>85000000</ScaleDenominator>
<CellSize>22489.6283125899</CellSize>
<PointOfOrigin>-34655800 39310000</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>8</MatrixWidth>
<MatrixHeight>8</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>2</tmsc:Identifier>
<ScaleDenominator>50000000</ScaleDenominator>
<CellSize>13229.1931250529</CellSize>
<PointOfOrigin>-34655800 39310000</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>13</MatrixWidth>
<MatrixHeight>14</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>3</tmsc:Identifier>
<ScaleDenominator>30000000</ScaleDenominator>
<CellSize>7937.51587503175</CellSize>
<PointOfOrigin>-34655800 39310000</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>21</MatrixWidth>
<MatrixHeight>22</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>4</tmsc:Identifier>
<ScaleDenominator>17500000</ScaleDenominator>
<CellSize>4630.21759376852</CellSize>
<PointOfOrigin>-34655800 39310000</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>36</MatrixWidth>
<MatrixHeight>38</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>5</tmsc:Identifier>
<ScaleDenominator>10000000</ScaleDenominator>
<CellSize>2645.83862501058</CellSize>
<PointOfOrigin>-34655800 39310000</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>62</MatrixWidth>
<MatrixHeight>66</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>6</tmsc:Identifier>
<ScaleDenominator>6000000</ScaleDenominator>
<CellSize>1587.50317500635</CellSize>
<PointOfOrigin>-34655800 39310000</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>103</MatrixWidth>
<MatrixHeight>110</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>7</tmsc:Identifier>
<ScaleDenominator>3500000</ScaleDenominator>
<CellSize>926.043518753704</CellSize>

```

```

<PointOfOrigin>-34655800 39310000</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>177</MatrixWidth>
<MatrixHeight>188</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>8</tmsc:Identifier>
<ScaleDenominator>2000000</ScaleDenominator>
<CellSize>529.167725002116</CellSize>
<PointOfOrigin>-34655800 39310000</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>309</MatrixWidth>
<MatrixHeight>329</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>9</tmsc:Identifier>
<ScaleDenominator>1200000</ScaleDenominator>
<CellSize>317.50063500127</CellSize>
<PointOfOrigin>-34655800 39310000</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>515</MatrixWidth>
<MatrixHeight>548</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>10</tmsc:Identifier>
<ScaleDenominator>700000</ScaleDenominator>
<CellSize>185.20870375074</CellSize>
<PointOfOrigin>-34655800 39310000</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>882</MatrixWidth>
<MatrixHeight>938</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>11</tmsc:Identifier>
<ScaleDenominator>420000</ScaleDenominator>
<CellSize>111.12522250444</CellSize>
<PointOfOrigin>-34655800 39310000</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>1470</MatrixWidth>
<MatrixHeight>1563</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>12</tmsc:Identifier>
<ScaleDenominator>250000</ScaleDenominator>
<CellSize>66.1459656252646</CellSize>
<PointOfOrigin>-34655800 39310000</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>2469</MatrixWidth>
<MatrixHeight>2626</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>13</tmsc:Identifier>
<ScaleDenominator>145000</ScaleDenominator>
<CellSize>38.3646600626534</CellSize>
<PointOfOrigin>-34655800 39310000</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>

```

```
<MatrixWidth>4257</MatrixWidth>
<MatrixHeight>4528</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>14</tmsc:Identifier>
<ScaleDenominator>85000</ScaleDenominator>
<CellSize>22.4896283125899</CellSize>
<PointOfOrigin>-34655800 39310000</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>7262</MatrixWidth>
<MatrixHeight>7723</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>15</tmsc:Identifier>
<ScaleDenominator>50000</ScaleDenominator>
<CellSize>13.2291931250529</CellSize>
<PointOfOrigin>-34655800 39310000</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>12344</MatrixWidth>
<MatrixHeight>13130</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>16</tmsc:Identifier>
<ScaleDenominator>30000</ScaleDenominator>
<CellSize>7.93751587503175</CellSize>
<PointOfOrigin>-34655800 39310000</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>20574</MatrixWidth>
<MatrixHeight>21882</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>17</tmsc:Identifier>
<ScaleDenominator>17500</ScaleDenominator>
<CellSize>4.63021759376852</CellSize>
<PointOfOrigin>-34655800 39310000</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>35269</MatrixWidth>
<MatrixHeight>37512</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>18</tmsc:Identifier>
<ScaleDenominator>10000</ScaleDenominator>
<CellSize>2.64583862501058</CellSize>
<PointOfOrigin>-34655800 39310000</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>61720</MatrixWidth>
<MatrixHeight>65646</MatrixHeight>
</TileMatrix>
<TileMatrix>
<tmsc:Identifier>19</tmsc:Identifier>
<ScaleDenominator>6000</ScaleDenominator>
<CellSize>1.58750317500635</CellSize>
<PointOfOrigin>-34655800 39310000</PointOfOrigin>
<TileWidth>256</TileWidth>
<TileHeight>256</TileHeight>
<MatrixWidth>102866</MatrixWidth>
<MatrixHeight>109409</MatrixHeight>
</TileMatrix>
```

```

<TileMatrix>
  <tmsc:Identifier>20</tmsc:Identifier>
  <ScaleDenominator>3500</ScaleDenominator>
  <CellSize>0.926043518753704</CellSize>
  <PointOfOrigin>-34655800 39310000</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>176341</MatrixWidth>
  <MatrixHeight>187558</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>21</tmsc:Identifier>
  <ScaleDenominator>2000</ScaleDenominator>
  <CellSize>0.529167725002116</CellSize>
  <PointOfOrigin>-34655800 39310000</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>308596</MatrixWidth>
  <MatrixHeight>328227</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>22</tmsc:Identifier>
  <ScaleDenominator>1200</ScaleDenominator>
  <CellSize>0.31750063500127</CellSize>
  <PointOfOrigin>-34655800 39310000</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>514327</MatrixWidth>
  <MatrixHeight>547044</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>23</tmsc:Identifier>
  <ScaleDenominator>700</ScaleDenominator>
  <CellSize>0.18520870375074</CellSize>
  <PointOfOrigin>-34655800 39310000</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>881703</MatrixWidth>
  <MatrixHeight>937790</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>24</tmsc:Identifier>
  <ScaleDenominator>420</ScaleDenominator>
  <CellSize>0.111125222250444</CellSize>
  <PointOfOrigin>-34655800 39310000</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>1469505</MatrixWidth>
  <MatrixHeight>1562983</MatrixHeight>
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>25</tmsc:Identifier>
  <ScaleDenominator>250</ScaleDenominator>
  <CellSize>0.0661459656252645</CellSize>
  <PointOfOrigin>-34655800 39310000</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>2468768</MatrixWidth>
  <MatrixHeight>2625811</MatrixHeight>
</TileMatrix>
</TileMatrixSet>

```

G

ANNEX G (INFORMATIVE) EXAMPLE ENCODINGS FOR VARIABLE MATRIX WIDTH TILEMATRIXSETS

ANNEX G (INFORMATIVE)

EXAMPLE ENCODINGS FOR VARIABLE MATRIX WIDTH TILEMATRIXSETS

This informative Annex provides examples of encodings for tile matrix sets using the Variable Matrix Width requirements class.

G.1. GNOSIS Global Grid

These are the JSON and XML definitions of the GNOSISGlobalGrid tile matrix set (see Annex E.1) that can be reproduced by other standards needing to define a tile matrix set. Not all TileMatrix elements need to be included and including other TileMatrices for more detailed scales is possible if they follow the same pattern.

One can define an arbitrary number of zoom levels. Here, 5 zoom levels are illustrated.

G.1.1. GNOSIS Global Grid (JSON encoding)

The complete JSON example can be found in the supplemental material described in Annex B

```
{
  "id" : "GNOSISGlobalGrid",
  "title" : "GNOSIS Global Grid",
  "uri" : "http://www.opengis.net/def/tilematrixset/OGC/1.0/GNOSISGlobalGrid",
  "crs" : "http://www.opengis.net/def/crs/EPSG/0/4326",
  "orderedAxes" : ["Lat", "Lon"],
  "wellKnownScaleSet" : "http://www.opengis.net/def/wkss/OGC/1.0/
GoogleCRS84Quad",
  "tileMatrices" : [
    {
      "id" : "0",
      "scaleDenominator" : 139770566.0071794390678,
      "cellSize" : 0.3515625,
      "cornerOfOrigin" : "topLeft",
      "pointOfOrigin" : [ 90, -180 ],
      "matrixWidth" : 4,
      "matrixHeight" : 2,
      "tileWidth" : 256,
      "tileHeight" : 256
    },
    {
      "id" : "1",
      "scaleDenominator" : 349426415.19275,
      "cellSize" : 0.17578125,
      "cornerOfOrigin" : "topLeft",
      "pointOfOrigin" : [ 45, -90 ],
      "matrixWidth" : 8,
      "matrixHeight" : 4,
      "tileWidth" : 128,
      "tileHeight" : 128
    },
    {
      "id" : "2",
      "scaleDenominator" : 87356603.7981875,
      "cellSize" : 0.087890625,
      "cornerOfOrigin" : "topLeft",
      "pointOfOrigin" : [ 22.5, -45 ],
      "matrixWidth" : 16,
      "matrixHeight" : 8,
      "tileWidth" : 64,
      "tileHeight" : 64
    },
    {
      "id" : "3",
      "scaleDenominator" : 21839150.947546875,
      "cellSize" : 0.04394765625,
      "cornerOfOrigin" : "topLeft",
      "pointOfOrigin" : [ 11.25, -22.5 ],
      "matrixWidth" : 32,
      "matrixHeight" : 16,
      "tileWidth" : 32,
      "tileHeight" : 32
    },
    {
      "id" : "4",
      "scaleDenominator" : 5459787.73688671875,
      "cellSize" : 0.0219738125,
      "cornerOfOrigin" : "topLeft",
      "pointOfOrigin" : [ 5.625, -11.25 ],
      "matrixWidth" : 64,
      "matrixHeight" : 32,
      "tileWidth" : 16,
      "tileHeight" : 16
    }
  ]
}
```

```

    "id" : "1",
    "scaleDenominator" : 69885283.0035897195339,
    "cellSize" : 0.17578125,
    "cornerOfOrigin" : "topLeft",
    "pointOfOrigin" : [ 90, -180 ],
    "matrixWidth" : 8,
    "matrixHeight" : 4,
    "tileWidth" : 256,
    "tileHeight" : 256,
    "variableMatrixWidths" : [
        { "coalesce" : 2, "minTileRow" : 0, "maxTileRow" : 0 },
        { "coalesce" : 2, "minTileRow" : 3, "maxTileRow" : 3 }
    ]
},
{
    "id" : "2",
    "scaleDenominator" : 34942641.501794859767,
    "cellSize" : 0.087890625,
    "cornerOfOrigin" : "topLeft",
    "pointOfOrigin" : [ 90, -180 ],
    "matrixWidth" : 16,
    "matrixHeight" : 8,
    "tileWidth" : 256,
    "tileHeight" : 256,
    "variableMatrixWidths" : [
        { "coalesce" : 4, "minTileRow" : 0, "maxTileRow" : 0 },
        { "coalesce" : 2, "minTileRow" : 1, "maxTileRow" : 1 },
        { "coalesce" : 2, "minTileRow" : 6, "maxTileRow" : 6 },
        { "coalesce" : 4, "minTileRow" : 7, "maxTileRow" : 7 }
    ]
},
{
    "id" : "3",
    "scaleDenominator" : 17471320.7508974298835,
    "cellSize" : 0.0439453125,
    "cornerOfOrigin" : "topLeft",
    "pointOfOrigin" : [ 90, -180 ],
    "matrixWidth" : 32,
    "matrixHeight" : 16,
    "tileWidth" : 256,
    "tileHeight" : 256,
    "variableMatrixWidths" : [
        { "coalesce" : 8, "minTileRow" : 0, "maxTileRow" : 0 },
        { "coalesce" : 4, "minTileRow" : 1, "maxTileRow" : 1 },
        { "coalesce" : 2, "minTileRow" : 2, "maxTileRow" : 3 },
        { "coalesce" : 2, "minTileRow" : 12, "maxTileRow" : 13 },
        { "coalesce" : 4, "minTileRow" : 14, "maxTileRow" : 14 },
        { "coalesce" : 8, "minTileRow" : 15, "maxTileRow" : 15 }
    ]
},
{
    "id" : "4",
    "scaleDenominator" : 8735660.3754487149417,
    "cellSize" : 0.02197265625,
    "cornerOfOrigin" : "topLeft",
    "pointOfOrigin" : [ 90, -180 ],
    "matrixWidth" : 64,
    "matrixHeight" : 32,
    "tileWidth" : 256,
    "tileHeight" : 256,
    "variableMatrixWidths" : [
        { "coalesce" : 16, "minTileRow" : 0, "maxTileRow" : 0 },
        { "coalesce" : 8, "minTileRow" : 1, "maxTileRow" : 1 },
    ]
}

```

```

        {
            "coalesce" : 4, "minTileRow" : 2, "maxTileRow" : 3 },
            "coalesce" : 2, "minTileRow" : 4, "maxTileRow" : 7 },
            "coalesce" : 2, "minTileRow" : 24, "maxTileRow" : 27 },
            "coalesce" : 4, "minTileRow" : 28, "maxTileRow" : 29 },
            "coalesce" : 8, "minTileRow" : 30, "maxTileRow" : 30 },
            "coalesce" : 16, "minTileRow" : 31, "maxTileRow" : 31 }
        ]
    }
}

```

G.1.2. GNOSIS Global Grid (XML encoding)

```

<?xml version="1.0" encoding="UTF-8"?>
<TileMatrixSet id="GNOSISGlobalGrid" xmlns="http://www.opengis.net/tms/2.0"
  xmlns:tmstc="http://www.opengis.net/tms/2.0/common" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="http://www.opengis.net/tms/2.0 ../../tilematrixset.xsd">
  <tmstc:Title>GNOSIS Global Grid</tmstc:Title>
  <tmstc:Identifier>GNOSISGlobalGrid</tmstc:Identifier>
  <uri>http://www.opengis.net/def/tilematrixset/OGC/1.0/GNOSISGlobalGrid</uri>
  <tmstc:CRS>
    <tmstc:URI>http://www.opengis.net/def/crs/EPSG/0/4326</tmstc:URI>
  </tmstc:CRS>
  <OrderedAxes>Lat,Lon</OrderedAxes>
  <WellKnownScaleSet>http://www.opengis.net/def/wkss/OGC/1.0/GoogleCRS84Quad</WellKnownScaleSet>
  <TileMatrix>
    <tmstc:Identifier>0</tmstc:Identifier>
    <ScaleDenominator>139770566.0071794</ScaleDenominator>
    <CellSize>0.3515625</CellSize>
    <PointOfOrigin>90 -180</PointOfOrigin>
    <TileWidth>256</TileWidth>
    <TileHeight>256</TileHeight>
    <MatrixWidth>4</MatrixWidth>
    <MatrixHeight>2</MatrixHeight>
  </TileMatrix>
  <TileMatrix>
    <tmstc:Identifier>1</tmstc:Identifier>
    <ScaleDenominator>69885283.00358972</ScaleDenominator>
    <CellSize>0.17578125</CellSize>
    <PointOfOrigin>90 -180</PointOfOrigin>
    <TileWidth>256</TileWidth>
    <TileHeight>256</TileHeight>
    <MatrixWidth>8</MatrixWidth>
    <MatrixHeight>4</MatrixHeight>
  </TileMatrix>
  <VariableMatrixWidth><Coalesce>2</Coalesce><MinTileRow>0</MinTileRow><MaxTileRow>0</MaxTileRow></VariableMatrixWidth>
  <VariableMatrixWidth><Coalesce>2</Coalesce><MinTileRow>3</MinTileRow><MaxTileRow>3</MaxTileRow></VariableMatrixWidth>
  </TileMatrix>
  <TileMatrix>
    <tmstc:Identifier>2</tmstc:Identifier>
    <ScaleDenominator>34942641.50179486</ScaleDenominator>
    <CellSize>0.087890625</CellSize>
    <PointOfOrigin>90 -180</PointOfOrigin>
    <TileWidth>256</TileWidth>
    <TileHeight>256</TileHeight>
    <MatrixWidth>16</MatrixWidth>
    <MatrixHeight>8</MatrixHeight>
  </TileMatrix>

```

```

<VariableMatrixWidth><Coalesce>4</Coalesce><MinTileRow>0</MinTileRow><MaxTileRow>0</MaxT
<VariableMatrixWidth><Coalesce>2</Coalesce><MinTileRow>1</MinTileRow><MaxTileRow>1</MaxT
<VariableMatrixWidth><Coalesce>2</Coalesce><MinTileRow>6</MinTileRow><MaxTileRow>6</MaxT
<VariableMatrixWidth><Coalesce>4</Coalesce><MinTileRow>7</MinTileRow><MaxTileRow>7</MaxT
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>3</tmsc:Identifier>
  <ScaleDenominator>17471320.7508974298835</ScaleDenominator>
  <CellSize>0.0439453125</CellSize>
  <PointOfOrigin>90 -180</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>32</MatrixWidth>
  <MatrixHeight>16</MatrixHeight>

<VariableMatrixWidth><Coalesce>8</Coalesce><MinTileRow>0</MinTileRow><MaxTileRow>0</MaxT
<VariableMatrixWidth><Coalesce>4</Coalesce><MinTileRow>1</MinTileRow><MaxTileRow>1</MaxT
<VariableMatrixWidth><Coalesce>2</Coalesce><MinTileRow>2</MinTileRow><MaxTileRow>3</MaxT
<VariableMatrixWidth><Coalesce>2</Coalesce><MinTileRow>12</MinTileRow><MaxTileRow>13</Ma
<VariableMatrixWidth><Coalesce>4</Coalesce><MinTileRow>14</MinTileRow><MaxTileRow>14</Ma
<VariableMatrixWidth><Coalesce>8</Coalesce><MinTileRow>15</MinTileRow><MaxTileRow>15</Ma
</TileMatrix>
<TileMatrix>
  <tmsc:Identifier>4</tmsc:Identifier>
  <ScaleDenominator>8735660.3754487149417</ScaleDenominator>
  <CellSize>0.02197265625</CellSize>
  <PointOfOrigin>90 -180</PointOfOrigin>
  <TileWidth>256</TileWidth>
  <TileHeight>256</TileHeight>
  <MatrixWidth>64</MatrixWidth>
  <MatrixHeight>32</MatrixHeight>

<VariableMatrixWidth><Coalesce>16</Coalesce><MinTileRow>0</MinTileRow><MaxTileRow>0</MaxT
<VariableMatrixWidth><Coalesce>8</Coalesce><MinTileRow>1</MinTileRow><MaxTileRow>1</MaxT
<VariableMatrixWidth><Coalesce>4</Coalesce><MinTileRow>2</MinTileRow><MaxTileRow>3</MaxT
<VariableMatrixWidth><Coalesce>2</Coalesce><MinTileRow>4</MinTileRow><MaxTileRow>7</MaxT
<VariableMatrixWidth><Coalesce>2</Coalesce><MinTileRow>24</MinTileRow><MaxTileRow>27</Ma
<VariableMatrixWidth><Coalesce>4</Coalesce><MinTileRow>28</MinTileRow><MaxTileRow>29</Ma
<VariableMatrixWidth><Coalesce>8</Coalesce><MinTileRow>30</MinTileRow><MaxTileRow>30</Ma
<VariableMatrixWidth><Coalesce>16</Coalesce><MinTileRow>31</MinTileRow><MaxTileRow>31</M
</TileMatrix>
</TileMatrixSet>

```

G.2. CDB 1 Global Grid

These are the JSON and XML definitions of the CDB1GlobalGrid tile matrix set (see Annex E.2) that can be reproduced by other standards needing to define a tile matrix set. Not all TileMatrix elements need to be included and including other TileMatrices for more detailed scales is possible if they follow the same pattern.

One can define an arbitrary number of zoom levels. Here, 3 zoom levels are illustrated.

G.2.1. CDB 1 Global Grid (JSON encoding)

```
{
  "id" : "CDB1GlobalGrid",
  "title" : "CDB 1 Global Grid",
  "uri" : "http://www.opengis.net/def/tilematrixset/OGC/1.0/CDB1GlobalGrid",
  "crs" : "http://www.opengis.net/def/crs/EPSG/0/4326",
  "orderedAxes" : ["Lat", "Lon"],
  "tileMatrices" : [
    {
      "id" : "-1",
      "scaleDenominator" : 776503.1444843303179,
      "cellSize" : 0.001953125,
      "cornerOfOrigin" : "topLeft",
      "pointOfOrigin" : [ 90, -180 ],
      "matrixWidth" : 360,
      "matrixHeight" : 180,
      "tileWidth" : 512,
      "tileHeight" : 512,
      "variableMatrixWidths" : [
        {
          "coalesce" : 12, "minTileRow" : 0, "maxTileRow" : 0 },
        {
          "coalesce" : 6, "minTileRow" : 1, "maxTileRow" : 9 },
        {
          "coalesce" : 4, "minTileRow" : 10, "maxTileRow" : 14 },
        {
          "coalesce" : 3, "minTileRow" : 15, "maxTileRow" : 19 },
        {
          "coalesce" : 2, "minTileRow" : 20, "maxTileRow" : 39 },
        {
          "coalesce" : 2, "minTileRow" : 140, "maxTileRow" : 159 },
        {
          "coalesce" : 3, "minTileRow" : 160, "maxTileRow" : 164 },
        {
          "coalesce" : 4, "minTileRow" : 165, "maxTileRow" : 169 },
        {
          "coalesce" : 6, "minTileRow" : 170, "maxTileRow" : 178 },
        {
          "coalesce" : 12, "minTileRow" : 179, "maxTileRow" : 179 }
      ]
    },
    {
      "id" : "0",
      "scaleDenominator" : 388251.572242165159,
      "cellSize" : 0.0009765625,
      "cornerOfOrigin" : "topLeft",
      "pointOfOrigin" : [ 90, -180 ],
      "matrixWidth" : 360,
      "matrixHeight" : 180,
      "tileWidth" : 1024,
      "tileHeight" : 1024,
      "variableMatrixWidths" : [
        {
          "coalesce" : 12, "minTileRow" : 0, "maxTileRow" : 0 },
        {
          "coalesce" : 6, "minTileRow" : 1, "maxTileRow" : 9 },
        {
          "coalesce" : 4, "minTileRow" : 10, "maxTileRow" : 14 },
        {
          "coalesce" : 3, "minTileRow" : 15, "maxTileRow" : 19 }
      ]
    }
  ]
}
```

```

        "coalesce" : 2, "minTileRow" : 20, "maxTileRow" : 39 },
        "coalesce" : 2, "minTileRow" : 140, "maxTileRow" : 159 },
        "coalesce" : 3, "minTileRow" : 160, "maxTileRow" : 164 },
        "coalesce" : 4, "minTileRow" : 165, "maxTileRow" : 169 },
        "coalesce" : 6, "minTileRow" : 170, "maxTileRow" : 178 },
        "coalesce" : 12, "minTileRow" : 179, "maxTileRow" : 179 }
    ],
},
{
    "id" : "1",
    "scaleDenominator" : 194125.7861210825795,
    "cellSize" : 0.00048828125,
    "cornerOfOrigin" : "topLeft",
    "pointOfOrigin" : [ 90, -180 ],
    "matrixWidth" : 720,
    "matrixHeight" : 360,
    "tileWidth" : 1024,
    "tileHeight" : 1024,
    "variableMatrixWidths" : [
        { "coalesce" : 12, "minTileRow" : 0, "maxTileRow" : 1 },
        { "coalesce" : 6, "minTileRow" : 2, "maxTileRow" : 19 },
        { "coalesce" : 4, "minTileRow" : 20, "maxTileRow" : 29 },
        { "coalesce" : 3, "minTileRow" : 30, "maxTileRow" : 39 },
        { "coalesce" : 2, "minTileRow" : 40, "maxTileRow" : 79 },
        { "coalesce" : 2, "minTileRow" : 280, "maxTileRow" : 319 },
        { "coalesce" : 3, "minTileRow" : 320, "maxTileRow" : 329 },
        { "coalesce" : 4, "minTileRow" : 330, "maxTileRow" : 339 },
        { "coalesce" : 6, "minTileRow" : 340, "maxTileRow" : 357 },
        { "coalesce" : 12, "minTileRow" : 358, "maxTileRow" : 359 }
    ]
}
]
}

```

G.2.2. CDB 1 Global Grid (XML encoding)

```

<?xml version="1.0" encoding="UTF-8"?>
<TileMatrixSet id="CDB1GlobalGrid" xmlns="http://www.opengis.net/tms/2.0"
  xmlns:tmSc="http://www.opengis.net/tms/2.0/common" xmlns:xsi="http://www.w3.
  org/2001/XMLSchema-instance" xsi:schemaLocation="http://www.opengis.net/tms/2.
  0 ../../tilematrixset.xsd">
  <tmSc:Title>CDB 1 Global Grid</tmSc:Title>
  <tmSc:Identifier>CDB1GlobalGrid</tmSc:Identifier>
  <uri>http://www.opengis.net/def/tilematrixset/OGC/1.0/CDB1GlobalGrid</uri>
  <tmSc:CRS>
    <tmSc:URI>http://www.opengis.net/def/crs/EPSG/0/4326</tmSc:URI>
  </tmSc:CRS>
  <OrderedAxes>Lat,Lon</OrderedAxes>
  <TileMatrix>
    <tmSc:Identifier>-1</tmSc:Identifier>
    <ScaleDenominator>776503.1444843302015</ScaleDenominator>
    <CellSize>0.001953125</CellSize>
    <PointOfOrigin>90 -180</PointOfOrigin>
    <TileWidth>512</TileWidth>
    <TileHeight>512</TileHeight>
    <MatrixWidth>360</MatrixWidth>
    <MatrixHeight>180</MatrixHeight>

    <VariableMatrixWidth><Coalesce>12</Coalesce><MinTileRow>0</MinTileRow><MaxTileRow>0</Max
  
```

```
<VariableMatrixWidth><Coalesce>6</Coalesce><MinTileRow>1</MinTileRow><MaxTileRow>9</MaxT
<VariableMatrixWidth><Coalesce>4</Coalesce><MinTileRow>10</MinTileRow><MaxTileRow>14</Ma
<VariableMatrixWidth><Coalesce>3</Coalesce><MinTileRow>15</MinTileRow><MaxTileRow>19</Ma
<VariableMatrixWidth><Coalesce>2</Coalesce><MinTileRow>20</MinTileRow><MaxTileRow>39</Ma
<VariableMatrixWidth><Coalesce>2</Coalesce><MinTileRow>140</MinTileRow><MaxTileRow>159</
<VariableMatrixWidth><Coalesce>3</Coalesce><MinTileRow>160</MinTileRow><MaxTileRow>164</
<VariableMatrixWidth><Coalesce>4</Coalesce><MinTileRow>165</MinTileRow><MaxTileRow>169</
<VariableMatrixWidth><Coalesce>6</Coalesce><MinTileRow>170</MinTileRow><MaxTileRow>178</
<VariableMatrixWidth><Coalesce>12</Coalesce><MinTileRow>179</MinTileRow><MaxTileRow>179<
  </TileMatrix>
  <TileMatrix>
    <tmsc:Identifier>0</tmsc:Identifier>
    <ScaleDenominator>388251.5722421651008</ScaleDenominator>
    <CellSize>0.0009765625</CellSize>
    <PointOfOrigin>90 -180</PointOfOrigin>
    <TileWidth>1024</TileWidth>
    <TileHeight>1024</TileHeight>
    <MatrixWidth>360</MatrixWidth>
    <MatrixHeight>180</MatrixHeight>

<VariableMatrixWidth><Coalesce>12</Coalesce><MinTileRow>0</MinTileRow><MaxTileRow>0</Max
<VariableMatrixWidth><Coalesce>6</Coalesce><MinTileRow>1</MinTileRow><MaxTileRow>9</MaxT
<VariableMatrixWidth><Coalesce>4</Coalesce><MinTileRow>10</MinTileRow><MaxTileRow>14</Ma
<VariableMatrixWidth><Coalesce>3</Coalesce><MinTileRow>15</MinTileRow><MaxTileRow>19</Ma
<VariableMatrixWidth><Coalesce>2</Coalesce><MinTileRow>20</MinTileRow><MaxTileRow>39</Ma
<VariableMatrixWidth><Coalesce>2</Coalesce><MinTileRow>140</MinTileRow><MaxTileRow>159</
<VariableMatrixWidth><Coalesce>3</Coalesce><MinTileRow>160</MinTileRow><MaxTileRow>164</
<VariableMatrixWidth><Coalesce>4</Coalesce><MinTileRow>165</MinTileRow><MaxTileRow>169</
<VariableMatrixWidth><Coalesce>6</Coalesce><MinTileRow>170</MinTileRow><MaxTileRow>178</
<VariableMatrixWidth><Coalesce>12</Coalesce><MinTileRow>179</MinTileRow><MaxTileRow>179<
  </TileMatrix>
  <TileMatrix>
    <tmsc:Identifier>1</tmsc:Identifier>
    <ScaleDenominator>194125.7861210825504</ScaleDenominator>
    <CellSize>0.00048828125</CellSize>
    <PointOfOrigin>90 -180</PointOfOrigin>
    <TileWidth>1024</TileWidth>
    <TileHeight>1024</TileHeight>
    <MatrixWidth>720</MatrixWidth>
    <MatrixHeight>360</MatrixHeight>

<VariableMatrixWidth><Coalesce>12</Coalesce><MinTileRow>0</MinTileRow><MaxTileRow>1</Max
<VariableMatrixWidth><Coalesce>6</Coalesce><MinTileRow>2</MinTileRow><MaxTileRow>19</Max
```

```
<VariableMatrixWidth><Coalesce>4</Coalesce><MinTileRow>20</MinTileRow><MaxTileRow>29</Ma  
<VariableMatrixWidth><Coalesce>3</Coalesce><MinTileRow>30</MinTileRow><MaxTileRow>39</Ma  
<VariableMatrixWidth><Coalesce>2</Coalesce><MinTileRow>40</MinTileRow><MaxTileRow>79</Ma  
<VariableMatrixWidth><Coalesce>2</Coalesce><MinTileRow>280</MinTileRow><MaxTileRow>319</  
<VariableMatrixWidth><Coalesce>3</Coalesce><MinTileRow>320</MinTileRow><MaxTileRow>329</  
<VariableMatrixWidth><Coalesce>4</Coalesce><MinTileRow>330</MinTileRow><MaxTileRow>339</  
<VariableMatrixWidth><Coalesce>6</Coalesce><MinTileRow>340</MinTileRow><MaxTileRow>357</  
<VariableMatrixWidth><Coalesce>12</Coalesce><MinTileRow>358</MinTileRow><MaxTileRow>359</  
  </TileMatrix>  
</TileMatrixSet>
```

H

ANNEX H (INFORMATIVE) EXAMPLE ENCODINGS FOR TILESETMETADATA

ANNEX H (INFORMATIVE)

EXAMPLE ENCODINGS FOR TILESETMETADATA

This informative Annex provides an example of use for *TileSetMetadata* and *TileMatrixSetLimits* data structures.

The *TileSetMetadata* data structure can be used for a resource to specify the tiling scheme supported by a particular tile set, as well as additional metadata.

The *TileMatrixSetLimits* data structure is populated to indicate that the resource is only available in a fragment of the tiled space.

H.1. Example JSON encoding of TileSetMetadata

This example illustrates a *TileSetMetadata* instance encoded in JSON.

```
{  
    "title" : "Daraa multi-layer vector tiles",  
    "description" : "Vector tiles of Daraa, Syria from NSG OpenStreetMap  
Topographic Data Store",  
    "keywords" : [ "Daraa", "Syria", "OpenStreetMap", "NSG", "TDS" ],  
    "dataType" : "vector",  
    "accessConstraints" : "unclassified",  
    "crs" : "http://www.opengis.net/def/crs/EPSG/0/3857",  
    "epoch" : 2021.33,  
    "links" : [  
        {  
            "rel" : "self",  
            "type" : "application/json",  
            "href" : "/Daraa/ogcapi/tiles/WebMercatorQuad?f=json"  
        },  
        {  
            "rel" : "alternate",  
            "type" : "application/json+vtnd.mapbox.tilejson",  
            "href" : "/Daraa/ogcapi/tiles/WebMercatorQuad?f=tilejson"  
        },  
        {  
            "rel" : "tiling-scheme",  
            "type" : "application/json",  
            "href" : "/Daraa/ogcapi/tileMatrixSets/WebMercatorQuad"  
        },  
        {  
            "rel" : "item",  
            "type" : "application/json",  
            "href" : "/Daraa/ogcapi/tiles/WebMercatorQuad?x=1&y=1&z=10"  
        }  
    ]  
}
```

```

        "href" : "/Daraa/ogcapi/tiles/WebMercatorQuad/{tileMatrix}/{tileRow}/{tileCol}",
        "templated" : true
    },
    {
        "rel" : "item",
        "href" : "/Daraa/ogcapi/tiles/WebMercatorQuad/{tileMatrix}/{tileRow}/{tileCol}.json",
        "type" : "application/geo+json",
        "templated" : true
    },
    {
        "rel" : "item",
        "href" : "/Daraa/ogcapi/tiles/WebMercatorQuad/{tileMatrix}/{tileRow}/{tileCol}.mvt",
        "type" : "application/vnd.mapbox-vector-tile",
        "templated" : true
    },
    {
        "rel" : "dataset",
        "href" : "/Daraa/ogcapi"
    }
],
"layers" : [
    {
        "id" : "AgricultureSrf",
        "dataType" : "vector",
        "geometryDimension" : "2",
        "maxTileMatrix" : "17",
        "minScaleDenominator" : 4265.4591676995678,
        "minCellSize" : 1.19432856696,
        "boundingBox" :
        {
            "crs" : "http://www.opengis.net/def/crs/OGC/1.3/CRS84",
            "lowerLeft": [35.898213, 32.4633913],
            "upperRight": [36.5614696, 32.8370158]
        },
        "geoDataClasses" : [ "http://example.com/def/geodataclasses/OSMNSGTDS" ]
    },
    "links" : [
        {
            "rel" : "http://www.opengis.net/def/rel/ogc/1.0/geodata",
            "href" : "/Daraa/ogcapi/collections/AgricultureSrf"
        }
    ],
    "propertiesSchema" :
    {
        "type": "object",
        "properties": {
            "F_CODE" :
            {
                "title" : "Feature Code",
                "type" : "string",
                "enum" : [ "EA010", "EA040", "AM020" ]
            },
            "FFN" : { "type" : "integer" },
            "FCSUBTYPE" :
            {
                "title" : "Feature subtype",
                "type" : "integer",
                "enum" : [ 100380, 100384 ]
            },
            "ZI005_FNA" : { "type" : "string" }
        }
    }
]
}

```

```

        }
    },
    {
        "id" : "TransportationGroundCrv",
        "dataType" : "vector",
        "geometryDimension" : "1",
        "maxTileMatrix" : "17",
        "minScaleDenominator" : 4265.4591676995678,
        "minCellSize" : 1.19432856696,
        "boundingBox" :
        {
            "crs" : "http://www.opengis.net/def/crs/OGC/1.3/CRS84",
            "lowerLeft": [35.9028738, 32.4168138],
            "upperRight": [36.5747694, 33.1424348]
        },
        "geoDataClasses" : [ "http://example.com/def/geodataclasses/OSMNSGTDS"
    ],
    "links" : [
        {
            "rel" : "http://www.opengis.net/def/rel/ogc/1.0/geodata",
            "href" : "/Daraa/ogcapi/collections/TransportationGroundCrv"
        }
    ],
    "propertiesSchema" :
    {
        "type": "object",
        "properties" :
        {
            "F_CODE" :
            {
                "title" : "Feature Code",
                "type" : "string",
                "enum" : [ "AN010", "AP010", "AP030", "AQ040" ]
            },
            "FFN" : { "type" : "integer" },
            "FCSUBTYPE" :
            {
                "title" : "Feature subtype",
                "type" : "integer",
                "enum" : [ 100143, 100152, 100161 ]
            },
            "ZI005_FNA" : { "type" : "string" }
        }
    }
],
"tileMatrixSetURI" : "http://www.opengis.net/def/tilematrixset/OGC/1.0/WebMercatorQuad",
"tileMatrixSetLimits" : [
    { "tileMatrix" : "0", "minTileRow" : 0, "maxTileRow" : 0, "minTileCol" : 0, "maxTileCol" : 0 },
    { "tileMatrix" : "1", "minTileRow" : 0, "maxTileRow" : 0, "minTileCol" : 1, "maxTileCol" : 1 },
    { "tileMatrix" : "2", "minTileRow" : 1, "maxTileRow" : 1, "minTileCol" : 2, "maxTileCol" : 2 },
    { "tileMatrix" : "3", "minTileRow" : 3, "maxTileRow" : 3, "minTileCol" : 4, "maxTileCol" : 4 },
    { "tileMatrix" : "4", "minTileRow" : 6, "maxTileRow" : 6, "minTileCol" : 9, "maxTileCol" : 19 },
    { "tileMatrix" : "5", "minTileRow" : 12, "maxTileRow" : 12, "minTileCol" : 19, "maxTileCol" : 19 }
]

```

```

        {
          "tileMatrix" : "6", "minTileRow" : 25, "maxTileRow" : 25, "minTileCol"
: 38, "maxTileCol" : 38 },
        {
          "tileMatrix" : "7", "minTileRow" : 51, "maxTileRow" : 51, "minTileCol"
: 76, "maxTileCol" : 77 },
        {
          "tileMatrix" : "8", "minTileRow" : 102, "maxTileRow" : 103,
"minTileCol" : 152, "maxTileCol" : 154 },
        {
          "tileMatrix" : "9", "minTileRow" : 205, "maxTileRow" : 207,
"minTileCol" : 305, "maxTileCol" : 308 },
        {
          "tileMatrix" : "10", "minTileRow" : 411, "maxTileRow" : 415,
"minTileCol" : 611, "maxTileCol" : 617 },
        {
          "tileMatrix" : "11", "minTileRow" : 823, "maxTileRow" : 831,
"minTileCol" : 1223, "maxTileCol" : 1234 },
        {
          "tileMatrix" : "12", "minTileRow" : 1646, "maxTileRow" : 1663,
"minTileCol" : 2446, "maxTileCol" : 2468 },
        {
          "tileMatrix" : "13", "minTileRow" : 3292, "maxTileRow" : 3326,
"minTileCol" : 4892, "maxTileCol" : 4937 },
        {
          "tileMatrix" : "14", "minTileRow" : 6584, "maxTileRow" : 6653,
"minTileCol" : 9784, "maxTileCol" : 9875 },
        {
          "tileMatrix" : "15", "minTileRow" : 13169, "maxTileRow" : 13306,
"minTileCol" : 19569, "maxTileCol" : 19751 },
        {
          "tileMatrix" : "16", "minTileRow" : 26339, "maxTileRow" : 26613,
"minTileCol" : 39139, "maxTileCol" : 39503 },
        {
          "tileMatrix" : "17", "minTileRow" : 52679, "maxTileRow" : 53227,
"minTileCol" : 78279, "maxTileCol" : 79007 }
      ],
      "boundingBox" :
{
      "crs" : "http://www.opengis.net/def/crs/OGC/1.3/CRS84",
      "lowerLeft" : [ 35, 32 ],
      "upperRight" : [ 37, 33.2671397 ]
},
      "centerPoint" :
{
      "crs" : "http://www.opengis.net/def/crs/OGC/1.3/CRS84",
      "coordinates" : [ 36.2298413, 32.65020355 ],
      "scaleDenominator" : 17061.8366707982,
      "cellSize" : 4.77731426782,
      "tileMatrix" : "15"
}
}

```

H.2. TileSetMetadata JSON Schema

The TileSetMetadata data structure can be included the definition of an API that provides tiles. This JSON Schema can be used in an API definition in JSON format and to validate the previous JSON example.

```
{
  "$schema": "https://json-schema.org/draft/2019-09/schema",
  "title": "Tile Set Metadata",
  "description": "A resource describing a tileset based on the OGC TileSet Metadata Standard. At least one of the 'TileMatrixSet', or a link with 'rel' http://www.opengis.net/def/rel/ogc/1.0/tiling-scheme",
  "type": "object",
  "required": ["dataType", "crs"],
  "properties":
  {
    "tileMatrixSets": [
      {
        "matrix": "15", "row": 1, "col": 1, "crs": "http://www.opengis.net/def/crs/OGC/1.3/CRS84", "lowerLeft": [35, 32], "upperRight": [37, 33.2671397]
      }
    ],
    "centerPoint": {
      "matrix": "15", "coordinates": [36.2298413, 32.65020355], "scaleDenominator": 17061.8366707982, "cellSize": 4.77731426782
    }
  }
}
```

```

"title": {
  "description": "A title for this tileset",
  "type": "string"
},
"description": {
  "description": "Brief narrative description of this tile set",
  "type": "string"
},
"keywords": {
  "description": "keywords about this tileset",
  "type": "array",
  "items": [
    {
      "type": "string"
    }
  ],
  "version": {
    "description": "Version of the Tile Set. Changes if the data behind the tiles has been changed",
    "type": "string"
  },
  "pointOfContact": {
    "description": "Useful information to contact the authors or custodians for the Tile Set",
    "type": "string"
  },
  "attribution": {
    "description": "Short reference to recognize the author or provider",
    "type": "string"
  },
  "license": {
    "description": "License applicable to the tiles",
    "type": "string"
  },
  "accessConstraints": {
    "description": "Restrictions on the availability of the Tile Set that the user needs to be aware of before using or redistributing the Tile Set",
    "type": "string",
    "default": "unclassified",
    "enum": ["unclassified", "restricted", "confidential", "secret",
    "topSecret"]
  },
  "mediaTypes": {
    "description": "Media types available for the tiles",
    "type": "array",
    "items": [
      {
        "type": "string"
      }
    ],
    "dataType": { "allOf": [
      { "description": "Type of data represented in the tileset" },
      { "$ref": "dataType.json" }
    ] },
    "tileMatrixSetLimits": {
      "description": "Limits for the TileRow and TileCol values for each TileMatrix in the tileMatrixSet. If missing, there are no limits other than the ones imposed by the TileMatrixSet. If present the TileMatrices listed are limited and the rest not available at all",
      "type": "array",
      "items": [
        {
          "$ref": "tileMatrixLimits.json"
        }
      ]
    }
  }
}

```

```

        }
    },
    "crs": { "allOf": [
      { "description": "Coordinate Reference System (CRS)" },
      { "$ref": "crs.json" }
    ] },
    "epoch": {
      "description": "Epoch of the Coordinate Reference System (CRS)",
      "type": "number"
    },
    "boundingBox": { "allOf": [
      { "description": "Minimum bounding rectangle surrounding the tile
matrix set, in the supported CRS" },
      { "$ref": "2DBoundingBox.json" }
    ] },
    "created": { "allOf": [
      { "description": "When the Tile Set was first produced" },
      { "$ref": "timeStamp.json" }
    ] },
    "updated": { "allOf": [
      { "description": "Last Tile Set change/revision" },
      { "$ref": "timeStamp.json" }
    ] },
    "layers": {
      "minItems": 1,
      "type": "array",
      "items": [
        {
          "$ref": "geospatialData.json"
        }
      ],
      "style": { "allOf": [
        { "description": "Style involving all layers used to generate the tileset"
      ],
        { "$ref": "style.json" }
      ] },
      "centerPoint": {
        "allOf": [
          { "description": "Location of a tile that nicely represents the tileset.
Implementations may use this center value to set the default location or to
present a representative tile in a user interface" },
          { "$ref": "tilePoint.json" }
        ]
      },
      "tileMatrixSet": {
        "description": "Tile matrix set definition",
        "$ref": "tileMatrixSet.json"
      },
      "tileMatrixSetURI": {
        "description": "Reference to a Tile Matrix Set on an official source for
Tile Matrix Sets such as the OGC-NA definition server (http://www.opengis.net/def/tms). Required if the tile matrix set is registered on an open official
source.",
        "type": "string",
        "format": "uri"
      },
      "links": [
        { "description": "Links to related resources. Possible link 'rel' values
are: 'http://www.opengis.net/def/rel/ogc/1.0/dataset' for a URL pointing
to the dataset, 'item' for a URL template to get a tile; 'alternate' for
a URL pointing to another representation of the TileSetMetadata (e.g a
dataset XML representation) and 'self' for a URL pointing to the TileSetMetadata
itself." }
      ]
    }
  }
}

```

```
TileJSON file); 'http://www.opengis.net/def/rel/ogc/1.0/tiling-scheme' for  
a definition of the TileMatrixSet; 'http://www.opengis.net/def/rel/ogc/1.0/  
geodata' for pointing to a single collection (if the tileset represents a  
single collection),  
    "type": "array",  
    "items": {  
        "$ref": "link.json"  
    }  
}  
}  
}
```

H.3. TileMatrixSetLimits JSON Schema

This JSON Schema is referenced by the TileSetMetadata schema to define limits for each tile matrix.

```
{
  "$schema": "https://json-schema.org/draft/2019-09/schema",
  "title": "TileMatrixLimits",
  "description": "The limits for an individual tile matrix of a TileSet's TileMatrixSet, as defined in the OGC 2D TileMatrixSet and TileSet Metadata Standard",
  "type": "object",
  "required": [
    "tileMatrix",
    "minTileRow",
    "maxTileRow",
    "minTileCol",
    "maxTileCol"
  ],
  "properties": {
    "tileMatrix": {
      "type": "string"
    },
    "minTileRow": {
      "type": "integer",
      "minimum": 0
    },
    "maxTileRow": {
      "type": "integer",
      "minimum": 0
    },
    "minTileCol": {
      "type": "integer",
      "minimum": 0
    },
    "maxTileCol": {
      "type": "integer",
      "minimum": 0
    }
  }
}
```

```
}
```

H.4. Example XML encoding of TileSetMetadata

This example illustrates a TileSetMetadata instance encoded in XML.

```
<?xml version="1.0" encoding="UTF-8"?>
<TileSetMetadata xmlns="http://www.opengis.net/tms/2.0" xmlns:tmSc="http://www.opengis.net/tms/2.0/common" xmlns:atom="http://www.w3.org/2005/Atom" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="http://www.opengis.net/tms/2.0 ../../tileset.xsd">
  <tmSc:Title>Daraa multi-layer vector tiles</tmSc:Title>
  <tmSc:Description>Vector tiles of Daraa, Syria from NSG OpenStreetMap Topographic Data Store</tmSc:Description>
  <tmSc:Keywords>
    <tmSc:Keyword>Daraa</tmSc:Keyword>
    <tmSc:Keyword>Syria</tmSc:Keyword>
    <tmSc:Keyword>OpenStreetMap</tmSc:Keyword>
    <tmSc:Keyword>NSG</tmSc:Keyword>
    <tmSc:Keyword>TDS</tmSc:Keyword>
  </tmSc:Keywords>
  <AccessConstraints>unclassified</AccessConstraints>
  <TileMatrixSetURI>http://www.opengis.net/def/TileMatrixset/OGC/1.0/WebMercatorQuad</TileMatrixSetURI>
  <tmSc:CRS>
    <tmSc:URI>http://www.opengis.net/def/crs/EPSG/0/3857</tmSc:URI>
  </tmSc:CRS>
  <Epoch>2021.33</Epoch>
  <TileMatrixSetLimit>
    <TileMatrix>0</TileMatrix>
    <MinTileRow>0</MinTileRow><MaxTileRow>0</MaxTileRow>
    <MinTileCol>0</MinTileCol><MaxTileCol>0</MaxTileCol>
  </TileMatrixSetLimit>
  <TileMatrixSetLimit>
    <TileMatrix>1</TileMatrix>
    <MinTileRow>0</MinTileRow><MaxTileRow>0</MaxTileRow>
    <MinTileCol>1</MinTileCol><MaxTileCol>1</MaxTileCol>
  </TileMatrixSetLimit>
  <TileMatrixSetLimit>
    <TileMatrix>2</TileMatrix>
    <MinTileRow>1</MinTileRow><MaxTileRow>1</MaxTileRow>
    <MinTileCol>2</MinTileCol><MaxTileCol>2</MaxTileCol>
  </TileMatrixSetLimit>
  <TileMatrixSetLimit>
    <TileMatrix>3</TileMatrix>
    <MinTileRow>3</MinTileRow><MaxTileRow>3</MaxTileRow>
    <MinTileCol>4</MinTileCol><MaxTileCol>4</MaxTileCol>
  </TileMatrixSetLimit>
  <TileMatrixSetLimit>
    <TileMatrix>4</TileMatrix>
    <MinTileRow>6</MinTileRow><MaxTileRow>6</MaxTileRow>
    <MinTileCol>9</MinTileCol><MaxTileCol>9</MaxTileCol>
  </TileMatrixSetLimit>
  <TileMatrixSetLimit>
    <TileMatrix>5</TileMatrix>
    <MinTileRow>12</MinTileRow><MaxTileRow>12</MaxTileRow>
    <MinTileCol>19</MinTileCol><MaxTileCol>19</MaxTileCol>
```

```

</TileMatrixSetLimit>
<TileMatrixSetLimit>
  <TileMatrix>6</TileMatrix>
  <MinTileRow>25</MinTileRow><MaxTileRow>25</MaxTileRow>
  <MinTileCol>38</MinTileCol><MaxTileCol>38</MaxTileCol>
</TileMatrixSetLimit>
<TileMatrixSetLimit>
  <TileMatrix>7</TileMatrix>
  <MinTileRow>51</MinTileRow><MaxTileRow>51</MaxTileRow>
  <MinTileCol>76</MinTileCol><MaxTileCol>77</MaxTileCol>
</TileMatrixSetLimit>
<TileMatrixSetLimit>
  <TileMatrix>8</TileMatrix>
  <MinTileRow>102</MinTileRow><MaxTileRow>103</MaxTileRow>
  <MinTileCol>152</MinTileCol><MaxTileCol>154</MaxTileCol>
</TileMatrixSetLimit>
<TileMatrixSetLimit>
  <TileMatrix>9</TileMatrix>
  <MinTileRow>205</MinTileRow><MaxTileRow>207</MaxTileRow>
  <MinTileCol>305</MinTileCol><MaxTileCol>308</MaxTileCol>
</TileMatrixSetLimit>
<TileMatrixSetLimit>
  <TileMatrix>10</TileMatrix>
  <MinTileRow>411</MinTileRow><MaxTileRow>415</MaxTileRow>
  <MinTileCol>611</MinTileCol><MaxTileCol>617</MaxTileCol>
</TileMatrixSetLimit>
<TileMatrixSetLimit>
  <TileMatrix>11</TileMatrix>
  <MinTileRow>823</MinTileRow><MaxTileRow>831</MaxTileRow>
  <MinTileCol>1223</MinTileCol><MaxTileCol>1234</MaxTileCol>
</TileMatrixSetLimit>
<TileMatrixSetLimit>
  <TileMatrix>12</TileMatrix>
  <MinTileRow>1646</MinTileRow><MaxTileRow>1663</MaxTileRow>
  <MinTileCol>2446</MinTileCol><MaxTileCol>2468</MaxTileCol>
</TileMatrixSetLimit>
<TileMatrixSetLimit>
  <TileMatrix>13</TileMatrix>
  <MinTileRow>3292</MinTileRow><MaxTileRow>3326</MaxTileRow>
  <MinTileCol>4892</MinTileCol><MaxTileCol>4937</MaxTileCol>
</TileMatrixSetLimit>
<TileMatrixSetLimit>
  <TileMatrix>14</TileMatrix>
  <MinTileRow>6584</MinTileRow><MaxTileRow>6653</MaxTileRow>
  <MinTileCol>9784</MinTileCol><MaxTileCol>9875</MaxTileCol>
</TileMatrixSetLimit>
<TileMatrixSetLimit>
  <TileMatrix>15</TileMatrix>
  <MinTileRow>13169</MinTileRow><MaxTileRow>13306</MaxTileRow>
  <MinTileCol>19569</MinTileCol><MaxTileCol>19751</MaxTileCol>
</TileMatrixSetLimit>
<TileMatrixSetLimit>
  <TileMatrix>16</TileMatrix>
  <MinTileRow>26339</MinTileRow><MaxTileRow>26613</MaxTileRow>
  <MinTileCol>39139</MinTileCol><MaxTileCol>39503</MaxTileCol>
</TileMatrixSetLimit>
<TileMatrixSetLimit>
  <TileMatrix>17</TileMatrix>
  <MinTileRow>52679</MinTileRow><MaxTileRow>53227</MaxTileRow>
  <MinTileCol>78279</MinTileCol><MaxTileCol>79007</MaxTileCol>
</TileMatrixSetLimit>
<tmsc:BoundingBox>
  <tmsc:LowerLeft>35 32</tmsc:LowerLeft>

```

```

<tmsc:UpperRight>37 33.2671397</tmsc:UpperRight>
</tmsc:BoundingBox>
<Layer>
  <tmsc:Identifier>AgricultureSrf</tmsc:Identifier>
  <GeometryDimension>2</GeometryDimension>
  <MinScaleDenominator>4265.4591676995678</MinScaleDenominator>
  <MinCellSize>1.19432856696</MinCellSize>
  <MaxTileMatrix>17</MaxTileMatrix>
  <tmsc:BoundingBox crs="http://www.opengis.net/def/crs/OGC/1.3/CRS84">
    <tmsc:LowerLeft>35.898213 32.4633913</tmsc:LowerLeft>
    <tmsc:UpperRight>36.5614696 32.8370158</tmsc:UpperRight>
  </tmsc:BoundingBox>
  <GeoDataClass>http://example.com/def/geodataclasses/OSMNSGTDS</GeoDataClass>
  <PropertySchema>
    <tmsc:Title>Feature Code</tmsc:Title>
    <Type>string</Type>
    <AcceptedValues>EA010</AcceptedValues>
    <AcceptedValues>EA040</AcceptedValues>
    <AcceptedValues>AM020</AcceptedValues>
    <tmsc:Identifier>F_CODE</tmsc:Identifier>
  </PropertySchema>
  <PropertySchema>
    <Type>integer</Type>
    <tmsc:Identifier>FFN</tmsc:Identifier>
  </PropertySchema>
  <PropertySchema>
    <tmsc:Title>Feature subtype</tmsc:Title>
    <Type>integer</Type>
    <AcceptedValues>100380</AcceptedValues>
    <AcceptedValues>100384</AcceptedValues>
    <tmsc:Identifier>FCSUBTYPE</tmsc:Identifier>
  </PropertySchema>
  <PropertySchema>
    <Type>string</Type>
    <tmsc:Identifier>ZI005_FNA</tmsc:Identifier>
  </PropertySchema>
  <Link rel="http://www.opengis.net/def/rel/ogc/1.0/geodata" href="/Daraa/ogcap
i/collections/AgricultureSrf"/>
  <DataType>vector</DataType>
</Layer>
<Layer>
  <tmsc:Identifier>TransportationGroundCrv</tmsc:Identifier>
  <GeometryDimension>1</GeometryDimension>
  <MinScaleDenominator>4265.4591676995678</MinScaleDenominator>
  <MinCellSize>1.19432856696</MinCellSize>
  <MaxTileMatrix>17</MaxTileMatrix>
  <tmsc:BoundingBox crs="http://www.opengis.net/def/crs/OGC/1.3/CRS84">
    <tmsc:LowerLeft>35.9028738 32.4168138</tmsc:LowerLeft>
    <tmsc:UpperRight>36.5747694 33.1424348</tmsc:UpperRight>
  </tmsc:BoundingBox>
  <GeoDataClass>http://example.com/def/geodataclasses/OSMNSGTDS</GeoDataClass>
  <PropertySchema>
    <tmsc:Title>Feature Code</tmsc:Title>
    <Type>string</Type>
    <AcceptedValues>AN010</AcceptedValues>
    <AcceptedValues>AP010</AcceptedValues>
    <AcceptedValues>AN030</AcceptedValues>
    <AcceptedValues>AQ040</AcceptedValues>
    <tmsc:Identifier>F_CODE</tmsc:Identifier>
  </PropertySchema>
  <PropertySchema>
    <Type>integer</Type>
    <tmsc:Identifier>FFN</tmsc:Identifier>
  </PropertySchema>

```

```

</PropertySchema>
<PropertySchema>
  <tmsc:Title>Feature subtype</tmsc:Title>
  <Type>integer</Type>
  <AcceptedValues>100143</AcceptedValues>
  <AcceptedValues>100152</AcceptedValues>
  <AcceptedValues>100161</AcceptedValues>
  <tmsc:Identifier>FCSUBTYPE</tmsc:Identifier>
</PropertySchema>
<PropertySchema>
  <Type>string</Type>
  <tmsc:Identifier>ZI005_FNA</tmsc:Identifier>
</PropertySchema>
<Link rel="http://www.opengis.net/def/rel/ogc/1.0/geodata" href="/Daraa/ogcap
i/collections/TransportationGroundCrv"/>
<DataType>vector</DataType>
</Layer>
<CenterPoint>
  <Coordinates>36.2298413 32.65020355</Coordinates>
  <ScaleDenominator>17061.8366707982</ScaleDenominator>
  <CellSize>4.77731426782</CellSize>
  <TileMatrix>15</TileMatrix>
</CenterPoint>
<Link rel="self" href="/Daraa/ogcapi/tiles/WebMercatorQuad?f=json" type=
"application/json" />
<Link rel="alternate" href="/Daraa/ogcapi/tiles/WebMercatorQuad?f=tilejson"
type="application/json+vnd.mapbox.tilejson" />
<Link rel="item" href="/Daraa/ogcapi/tiles/WebMercatorQuad/{TileMatrix}/{tileR
ow}/{tileCol}" templated="true" />
<Link rel="item" href="/Daraa/ogcapi/tiles/WebMercatorQuad/{TileMatrix}/{tileR
ow}/{tileCol}.json" type="application/geo+json" templated="true" />
<Link rel="item" href="/Daraa/ogcapi/tiles/WebMercatorQuad/{TileMatrix}/{tileR
ow}/{tileCol}.mvt" type="application/vnd.mapbox-vector-tile" templated="true" /
>
<Link rel="dataset" href="/Daraa/ogcapi" />
<Link rel="tiling-scheme" href="/Daraa/ogcapi/TileMatrixSets/WebMercatorQuad"
type="application/json" />
<DataType>vector</DataType>
</TileSetMetadata>

```

H.5. TileSetMetadata XML Schema

This XML Schema can be used to validate the previous XML example.

```

<?xml version="1.0" encoding="UTF-8"?>
<!-- Edited with XMLSpy v2008 sp1 (http://www.altova.com) by Joan Masó
(UAB-CREAF-MiraMon). Based on previous documents of Keith Pomakis. --&gt;
&lt;schema xmlns="http://www.w3.org/2001/XMLSchema" xmlns:tms="http://www.opengis.
net/tms/2.0" xmlns:atom="http://www.w3.org/2005/Atom" xmlns:tmsc="http://www.
opengis.net/tms/2.0/common" targetNamespace="http://www.opengis.net/tms/2.0"
elementFormDefault="qualified" xml:lang="en"&gt;
&lt;annotation&gt;
  &lt;appinfo&gt;TileMatrixSet 2021-02-02&lt;/appinfo&gt;
  &lt;documentation&gt;
    This XML Schema Document encodes the TileMatrisSet data structures.
    TMS is an OGC Standard Copyright (c) 2021 Open Geospatial Consortium, Inc.
    All Rights Reserved.
  &lt;/documentation&gt;
&lt;/annotation&gt;
</pre>

```

```

    To obtain additional rights of use, visit http://www.opengeospatial.org/
legal..
</documentation>
</annotation>
<!-- **** Includes and imports.
Includes and imports.

***** -->
<include schemaLocation="tilematrixset.xsd"/>
<include schemaLocation="tilematrixlimits.xsd"/>
<import namespace="http://www.w3.org/2005/Atom" schemaLocation="../../../../../
kml/2.3/atom-author-link.xsd"/>
<import namespace="http://www.opengis.net/tms/2.0/common" schemaLocation=
"common.xsd"/>
<!--
***** -->
<!-- ** The TileMatrixSetLink, TileMatrixSetLimits and TileMatrixLimits
element. ** -->
<!--
***** -->
<element name="TileSetMetadata">
<annotation>
    <documentation>Metadata about the TileMatrixSet reference.</documentation>
</annotation>
<complexType>
<complexContent>
    <extension base="tmsc:DescriptionType">
        <sequence>
            <element name="Version" type="string" minOccurs="0">
                <annotation>
                    <documentation>Version of the Tile Set. Changes if the data behind the
tiles has been changed</documentation>
                </annotation>
            </element>
            <element name="PointOfContact" type="string" minOccurs="0">
                <annotation>
                    <documentation>Useful information to contact the authors or custodians
for the Tile Set</documentation>
                </annotation>
            </element>
            <element name="Attribution" type="string" minOccurs="0">
                <annotation>
                    <documentation>Short reference to recognize the author or
provider</documentation>
                </annotation>
            </element>
            <element name="License" type="string" minOccurs="0">
                <annotation>
                    <documentation>License applicable to the tiles</documentation>
                </annotation>
            </element>
            <element name="AccessConstraints" minOccurs="0">
                <annotation>
                    <documentation>Restrictions on the availability of the Tile Set
that the user needs to be aware of before using or redistributing the Tile
Set</documentation>
                </annotation>
            </simpleType>
                <restriction base="string">
                    <enumeration value="unclassified"/>
                    <enumeration value="restricted"/>

```

```

<enumeration value="confidential"/>
<enumeration value="secret"/>
<enumeration value="topSecret"/>
</restriction>
</simpleType>
</element>
<element name="MediaType" type="tmsc:MediaTypeType" minOccurs="0"
maxOccurs="unbounded">
<annotation>
<documentation>Media types available for the tiles</documentation>
</annotation>
</element>
<element ref="tms:TileMatrixSet" minOccurs="0">
<annotation>
<documentation>A tileMatrixSet definition</documentation>
</annotation>
</element>
<element name="TileMatrixSetURI" type="anyURI" minOccurs="0">
<annotation>
<documentation>Reference to a tileMatrixSet. Points to a definition
of the TileMatrixSet on an official source for the Tile Matrix Set
definitions such as the OGC-NA definition server (http://www.opengis.net/def/tms)</documentation>
</annotation>
</element>
<element ref="tmsc:CRS">
<annotation>
<documentation>Coordinate Reference System (CRS)</documentation>
</annotation>
</element>
<element name="Epoch" type="double" minOccurs="0">
<annotation>
<documentation>Epoch of the Coordinate Reference System
(CRS)</documentation>
</annotation>
</element>
<element ref="tms:TileMatrixSetLimit" minOccurs="0" maxOccurs=
"unbounded">
<annotation>
<documentation>Limits for the TileRow and TileCol values for each
TileMatrix in the tileMatrixSet. If missing, there are no limits other than
the ones imposed by the TileMatrixSet. If present the TileMatrices listed are
limited and the rest not available at all</documentation>
</annotation>
</element>
<element ref="tmsc:BoundingBox" minOccurs="0">
<annotation>
<documentation>
Minimum bounding rectangle surrounding
the visible layer presented by this tile matrix
set, in the supported CRS </documentation>
</annotation>
</element>
<element name="Created" type="dateTime" minOccurs="0">
<annotation>
<documentation>Timestamp indicating when the Tile Set was first
produced</documentation>
</annotation>
</element>
<element name="Updated" type="dateTime" minOccurs="0">
<annotation>
<documentation>Timestamp of the last Tile Set change/
revision</documentation>

```

```

        </annotation>
    </element>
<element ref="tms:Layer" minOccurs="0" maxOccurs="unbounded">
    <annotation>
        <documentation>Style involving all layers used to generate the
tileset</documentation>
    </annotation>
    </element>
<element ref="tms:Style" minOccurs="0">
    <annotation>
        <documentation>Style involving all layers used to generate the
tileset</documentation>
    </annotation>
    </element>
<element ref="tms:CenterPoint" minOccurs="0">
    <annotation>
        <documentation>Location of a tile that nicely represents the tileset.
Implementations may use this center value to set the default location or to
present a representative tile in a user interface</documentation>
    </annotation>
    </element>
<element ref="tms:Link" minOccurs="0" maxOccurs="unbounded">
    <annotation>
        <documentation>Links to related resources. Possible link 'rel' values
are: 'dataset' for a URL pointing to the dataset, 'item' for a URL template to
get a tile; 'alternate' for a URL pointing to another representation of the
TileSetMetadata (e.g a TileJSON file); 'tiling-scheme' for a definition of the
TileMatrixSet; 'geodata' for pointing to a single collection (if the tileset
represents a single collection)</documentation>
    </annotation>
    </element>
<element name="DataType" type="tms:DataTypeOrStringType">
    <annotation>
        <documentation>Type of data represented in the tiles</documentation>
    </annotation>
    </element>
<any namespace="#other" processContents="lax" minOccurs="0" maxOccurs=
"unbounded">
    <annotation>
        <documentation>This is an extension point for other properties in the
TileMatrixSet.</documentation>
    </annotation>
    </any>
</sequence>
<attribute name="id" type="string">
    <annotation>
        <documentation/>
    </annotation>
    </attribute>
</extension>
</complexContent>
</complexType>
</element>
<!-- ===== -->
<element name="Layer" type="tms:GeospatialDataType"/>
<complexType name="GeospatialDataType">
    <annotation>
        <documentation>Geospatial data type</documentation>
    </annotation>
    <complexContent>
        <extension base="tmsc:DescriptionType">
            <sequence>
                <element ref="tmsc:Identifier">

```

```

<annotation>
  <documentation>Unique identifier of the Layer. Implementation of
'identifier'</documentation>
</annotation>
</element>
<element name="GeometryDimension" minOccurs="0">
  <annotation>
    <documentation>The geometry dimension of the features shown in this
layer (0: points, 1: curves, 2: surfaces, 3: solids, unspecified: mixed or
unknown.</documentation>
  </annotation>
  <simpleType>
    <restriction base="integer">
      <minInclusive value="0"/>
      <maxInclusive value="3"/>
    </restriction>
  </simpleType>
</element>
<element name="FeatureType" type="string" minOccurs="0" maxOccurs=
"unbounded">
  <annotation>
    <documentation>Feature type identifier. Only applicable to layers of
datatype 'geometries'</documentation>
  </annotation>
</element>
<element name="PointOfContact" type="string" minOccurs="0">
  <annotation>
    <documentation>Useful information to contact the authors or custodians
for the layer. (e.g. e-mail address, a physical address, phone numbers,
etc)</documentation>
  </annotation>
</element>
<element name="Attribution" type="string" minOccurs="0">
  <annotation>
    <documentation>Short reference to recognize the author or
provider</documentation>
  </annotation>
</element>
<element name="License" type="string" minOccurs="0">
  <annotation>
    <documentation>License applicable to the tiles</documentation>
  </annotation>
</element>
<element name="Publisher" type="string" minOccurs="0">
  <annotation>
    <documentation>Organization or individual responsible for making the
layer available</documentation>
  </annotation>
</element>
<element name="Theme" type="string" minOccurs="0" maxOccurs="unbounded">
  <annotation>
    <documentation>Category where the layer can be grouped</documentation>
  </annotation>
</element>
<element ref="tmsc:CRS" minOccurs="0">
  <annotation>
    <documentation>Coordinate Reference System (CRS)</documentation>
  </annotation>
</element>
<element name="Epoch" type="double" minOccurs="0">
  <annotation>
    <documentation>Epoch of the Coordinate Reference System
(CRS)</documentation>

```

```

        </annotation>
    </element>
    <element name="MinScaleDenominator" type="double" minOccurs="0">
        <annotation>
            <documentation>Minimum scale denominator for usage of the
layer</documentation>
        </annotation>
    </element>
    <element name="MaxScaleDenominator" type="double" minOccurs="0">
        <annotation>
            <documentation>Maximum scale denominator for usage of the
layer</documentation>
        </annotation>
    </element>
    <element name="MinCellSize" type="double" minOccurs="0">
        <annotation>
            <documentation>Minimum cel size for usage of the layer</documentation>
        </annotation>
    </element>
    <element name="MaxCellSize" type="double" minOccurs="0">
        <annotation>
            <documentation>Maximum cell size for usage of the layer</documentation>
        </annotation>
    </element>
    <element name="MaxTileMatrix" type="tmsc:CodeType" minOccurs="0">
        <annotation>
            <documentation>TileMatrix identifier associated with the
MinScaleDenominator</documentation>
        </annotation>
    </element>
    <element name="MinTileMatrix" type="tmsc:CodeType" minOccurs="0">
        <annotation>
            <documentation>TileMatrix identifier associated with the
MaxScaleDenominator</documentation>
        </annotation>
    </element>
    <element ref="tmsc:BoundingBox" minOccurs="0">
        <annotation>
            <documentation>Minimum bounding rectangle surrounding the
layer</documentation>
        </annotation>
    </element>
    <element name="Created" type="dateTime" minOccurs="0">
        <annotation>
            <documentation>Timestamp indicating when the layer was first
produced</documentation>
        </annotation>
    </element>
    <element name="Updated" type="dateTime" minOccurs="0">
        <annotation>
            <documentation>Timestamp of the last layer change/
revision</documentation>
        </annotation>
    </element>
    <element ref="tms:Style" minOccurs="0" maxOccurs="unbounded">
        <annotation>
            <documentation>Style used to generate the layer in the
tileset</documentation>
        </annotation>
    </element>
    <element name="GeoDataClass" type="tmsc:CodeType" minOccurs="0" maxOccurs=
"unbounded">
        <annotation>

```

```

<documentation>URI identifying a class of data contained in this layer
(useful to determine compatibility with styles or processes)</documentation>
</annotation>
</element>
<element ref="tms:PropertySchema" minOccurs="0" maxOccurs="unbounded">
<annotation>
<documentation>Properties represented by the features in this layer.
Can be the attributes of a feature dataset (datatype=geometries) or the
rangeType of a coverage (datatype=coverage)</documentation>
</annotation>
</element>
<element ref="tms:Link" minOccurs="0" maxOccurs="unbounded">
<annotation>
<documentation>Links related to this layer. Possible link 'rel' values
are: 'geodata' for a URL pointing to the collection of geospatial data.
</documentation>
</annotation>
</element>
<element name="DataType" type="tms:DataTypeOrStringType">
<annotation>
<documentation>Type of data represented in the layer</documentation>
</annotation>
</element>
<any namespace="##other" processContents="lax" minOccurs="0" maxOccurs=
"unbounded">
<annotation>
<documentation>This is an extension point for other properties in the
TileMatrixSet.</documentation>
</annotation>
</any>
</sequence>
<attribute name="id" type="string">
<annotation>
<documentation/>
</annotation>
</attribute>
</extension>
</complexContent>
</complexType>
<!-- ===== -->
<element name="PropertySchema" type="tms:FeatureAttributeType"/>
<complexType name="FeatureAttributeType">
<annotation>
<documentation>Properties represented by the features in this layer. Can be
the attributes of a feature dataset (datatype=geometries) or the rangeType of
a coverage (datatype=coverage)</documentation>
</annotation>
<complexContent>
<extension base="tmsc:DescriptionType">
<sequence>
<element name="Type" type="string">
<annotation>
<documentation>The data type of the attribute</documentation>
</annotation>
</element>
<element name="Pattern" type="string" minOccurs="0">
<annotation>
<documentation>Regular expression to validate the values of the
attribute</documentation>
</annotation>
</element>
<element name="MediaType" type="tmsc:MediaTypeType" minOccurs="0">
<annotation>

```

```

<documentation>Encodings of a complex attribute (e.g. an image/png)</documentation>
</annotation>
</element>
<element name="AcceptedValues" type="string" minOccurs="0" maxOccurs="unbounded">
    <annotation>
        <documentation>Valid values of the attribute</documentation>
    </annotation>
</element>
<element name="Range" type="string" minOccurs="0" maxOccurs="2">
    <annotation>
        <documentation>Range of valid values expressed as an array of two items</documentation>
    </annotation>
</element>
<element name="lowerMultiplicity" type="nonNegativeInteger" minOccurs="0">
    <annotation>
        <documentation>Lower multiplicity of the attribute. Default is 0 (optional)</documentation>
    </annotation>
</element>
<element name="upperMultiplicity" type="nonNegativeInteger" minOccurs="0">
    <annotation>
        <documentation>Upper multiplicity of the attribute. Default is many (unbounded)</documentation>
    </annotation>
</element>
<element name="ObservedProperty" type="string" minOccurs="0">
    <annotation>
        <documentation>Measured phenomenon (variable) label, commonly a descriptive name</documentation>
    </annotation>
</element>
<element name="ObservedPropertyURI" type="anyURI" minOccurs="0">
    <annotation>
        <documentation>URI pointing to a representation of the definition of the measured phenomenon (variable)</documentation>
    </annotation>
</element>
<element name="UoM" type="string" minOccurs="0">
    <annotation>
        <documentation>Units of measure characterizing the values of the attribute</documentation>
    </annotation>
</element>
<element name="UoMURI" type="anyURI" minOccurs="0">
    <annotation>
        <documentation>URI pointing to a representation of the definition of the units of measure characterizing the values of the attribute</documentation>
    </annotation>
</element>
<element ref="tmsc:Identifier">
    <annotation>
        <documentation>Unique identifier of the attribute</documentation>
    </annotation>
</element>
<any namespace="##other" processContents="lax" minOccurs="0" maxOccurs="unbounded">
    <annotation>
        <documentation>This is an extension point for other properties in the TileMatrixSet.</documentation>
    </annotation>

```

```

        </any>
    </sequence>
</extension>
</complexContent>
</complexType>
<!-- ===== -->
<element name="Style" type="tms:StyleType"/>
<complexType name="StyleType">
<annotation>
    <documentation>Style used to generate the tiles</documentation>
</annotation>
<complexContent>
    <extension base="tmsc:DescriptionType">
        <sequence>
            <element ref="tms:Link" minOccurs="0" maxOccurs="unbounded">
                <annotation>
                    <documentation>Links to related resources. Possible link 'rel' values are: 'style' for a URL pointing to the style description, 'styleSpec' for a URL pointing to the specification or standard used to define the style</documentation>
                </annotation>
            </element>
            <element ref="tmsc:Identifier">
                <annotation>
                    <documentation>Unique identifier of the style</documentation>
                </annotation>
            </element>
            <any namespace="#other" processContents="lax" minOccurs="0" maxOccurs="unbounded">
                <annotation>
                    <documentation>This is an extension point for other properties in the TileMatrixSet.</documentation>
                </annotation>
            </any>
        </sequence>
    </extension>
</complexContent>
</complexType>
<!-- ===== -->
<simpleType name="DataTypeType">
<annotation>
    <documentation>Data type for tiles and layers</documentation>
</annotation>
<restriction base="string">
    <enumeration value="map"/>
    <enumeration value="vector"/>
    <enumeration value="coverage"/>
</restriction>
</simpleType>
<simpleType name="DataTypeOrStringType">
<union memberTypes="tms:DataTypeType string"/>
</simpleType>
<!-- ===== -->
<element name="CenterPoint" type="tms:TilePointType"/>
<complexType name="TilePointType">
<annotation>
    <documentation>Point in a tile matrix</documentation>
</annotation>
<sequence>
    <element name="Coordinates" type="tmsc:PositionType">
        <annotation>
            <documentation>Location of the center point of the tile set.</documentation>
        </annotation>
    </element>
</sequence>
</complexType>

```

```

        </annotation>
    </element>
<element ref="tmsc:CRS" minOccurs="0">
    <annotation>
        <documentation>Coordinate Reference System (CRS)</documentation>
    </annotation>
</element>
<element name="ScaleDenominator" type="double" minOccurs="0">
    <annotation>
        <documentation>Scale denominator of the tile matrix selected</documentation>
    </annotation>
</element>
<element name="CellSize" type="double" minOccurs="0">
    <annotation>
        <documentation>Cell size of the tile matrix selected</documentation>
    </annotation>
</element>
<element name="TileMatrix" type="tmsc:CodeType" minOccurs="0">
    <annotation>
        <documentation>TileMatrix identifier associated with the scaleDenominator</documentation>
    </annotation>
</element>
</sequence>
</complexType>
<element name="Link" type="tms:LinkType"/>
<complexType name="LinkType">
    <annotation>
        <documentation>Templated link based on atom link</documentation>
    </annotation>
    <attribute name="href" use="required"/>
    <attribute name="rel"/>
    <attribute name="type" type="atom:atomMediaType"/>
    <attribute name="hreflang" type="atom:atomLanguageTag"/>
    <attribute name="title"/>
    <attribute name="length"/>
    <attribute name="templated"/>
</complexType>
</schema>

```

H.6. TileMatrixSetLimits XML Schema

This XML Schema is referenced by the TileSetMetadata schema to define limits for each tile matrix.

```

<?xml version="1.0" encoding="UTF-8"?>
<!-- Edited with XMLSpy v2008 sp1 (<a href="http://www.altova.com">http://www.altova.com) by Joan Masó (UAB-CREAF-MiraMon). Based on previous documents of Keith Pomakis. -->
<schema xmlns="http://www.w3.org/2001/XMLSchema" xmlns:tms="http://www.opengis.net/tms/2.0" targetNamespace="http://www.opengis.net/tms/2.0" elementFormDefault="qualified" xml:lang="en">
    <annotation>
        <appinfo>TileMatrixSet 2021-02-02</appinfo>
        <documentation>
            This XML Schema Document encodes the TileMatrisSet data structures.
            TMS is an OGC Standard Copyright (c) 2021 Open Geospatial Consortium, Inc.
            All Rights Reserved.
        </documentation>
    </annotation>

```

```

    To obtain additional rights of use, visit http://www.opengeospatial.org/
legal/.

</documentation>
</annotation>
<!-- **** Includes and imports.

***** -->
<!--import namespace="http://www.w3.org/1999/xlink" schemaLocation="../../../../../
xlink/1.0.0/xlinks.xsd"-->
<!--
***** -->
<!-- ** TileMatrixSetLimits and TileMatrixLimits element.
      ** -->
<!--
***** -->
-->
<element name="TileMatrixSetLimit">
<annotation>
  <documentation>Metadata describing the limits of a TileMatrix
    for this layer.</documentation>
</annotation>
<complexType>
<sequence>
  <element name="TileMatrix" type="string">
    <annotation>
      <documentation>Reference to a TileMatrix identifier</documentation>
    </annotation>
  </element>
  <element name="MinTileRow" type="nonNegativeInteger">
    <annotation>
      <documentation>Minimum tile row index valid for this
        layer. From 0 to maxTileRow</documentation>
    </annotation>
  </element>
  <element name="MaxTileRow" type="nonNegativeInteger">
    <annotation>
      <documentation>Maximim tile row index valid for this
        layer. From minTileRow to matrixWidth-1 of the tileMatrix
        section of this tileMatrixSet</documentation>
    </annotation>
  </element>
  <element name="MinTileCol" type="nonNegativeInteger">
    <annotation>
      <documentation>Minimum tile column index valid for this
        layer. From 0 to maxTileCol</documentation>
    </annotation>
  </element>
  <element name="MaxTileCol" type="nonNegativeInteger">
    <annotation>
      <documentation>Maximim tile column index valid for this layer.
        From minTileCol to tileHeight-1 of the tileMatrix section
        of this tileMatrixSet.</documentation>
    </annotation>
  </element>
  <any namespace="#other" processContents="lax" minOccurs="0" maxOccurs=
"unbounded">
    <annotation>
      <documentation>This is an extension point for other properties in the
        TileMatrixLimits.</documentation>
    </annotation>
  </any>

```

```
</sequence>
</complexType>
</element>
</schema>
```

I

ANNEX I (INFORMATIVE) PSEUDOCODE

ANNEX I (INFORMATIVE) PSEUDOCODE

This informative Annex provides pseudocode that illustrates how to get the tiles that cover a bounding box rectangle and how to get the CRS coordinates that bound a tile.

I.1. From BBOX to tile indices

The following fragment of pseudocode could be used to convert from a desired bounding box (`bBoxMinX`, `bBoxMinY`, `bBoxMaxX`, `bBoxMaxY`) in CRS coordinates to a range of tile set indices. This pseudocode uses the same notation that subclause 6.1.1 uses. In this pseudocode it is assumed that `bBoxMinX`, `bBoxMinY`, `bBoxMaxX`, `bBoxMaxY`, `tileMatrixMinX`, `tileMatrixMinY`, `tileMatrixMaxY`, `tileSpanX` and `tileSpanY` are floating point variables (IEEE-754) that have accuracy issues derived from the finite precision of the representation. These accuracy issues could be amplified in a typical `floor()` rounding down function that could return a value ± 1 than what is expected. To overcome this issue this code uses a small value (`epsilon`) added or subtracted in a place that is not affected by CRS coordinate precision.

```
// to compensate for floating point computation inaccuracies
epsilon = 1e-6

tileMinCol = floor((bBoxMinX - tileMatrixMinX) / tileSpanX + epsilon)
tileMaxCol = floor((bBoxMaxX - tileMatrixMinX) / tileSpanX - epsilon)
tileMinRow = floor((tileMatrixMaxY - bBoxMaxY) / tileSpanY + epsilon)
tileMaxRow = floor((tileMatrixMaxY - bBoxMinY) / tileSpanY - epsilon)

// to avoid requesting out-of-range tiles
if (tileMinCol < 0) tileMinCol = 0
if (tileMaxCol >= matrixWidth) tileMaxCol = matrixWidth-1
if (tileMinRow < 0) tileMinRow = 0
if (tileMaxRow >= matrixHeight) tileMaxRow = matrixHeight-1
```

To fetch all the tiles that cover this bounding box, a client would scan through `tileMinCol` to `tileMaxCol` and `tileMinRow` to `tileMaxRow`, all inclusive. A total of $(\text{tileMaxCol} - \text{tileMinCol} + 1) \times (\text{tileMaxRow} - \text{tileMinRow} + 1)$ will be fetched.

I.2. From tile indices to BBOX

The following pseudocode could be used to convert from a pair of tile indices (tileCol, tileRow) to the bounding box (in CRS coordinates) of this tile defined by the upper-left corner (leftX, upperY) of the tile:

```
leftX = tileCol * tileSpanX + tileMatrixMinX  
upperY = tileMatrixMaxY - tileRow * tileSpanY
```

and the lower-right corner (rightX, lowerY) of the tile:

```
rightX = (tileCol+1) * tileSpanX + tileMatrixMinX  
lowerY = tileMatrixMaxY - (tileRow+1) * tileSpanY
```



J

ANNEX J (INFORMATIVE) EXTENDING TILEMATRIXSETS FOR ADDITIONAL DIMENSIONS

ANNEX J (INFORMATIVE)

EXTENDING TILEMATRIXSETS FOR ADDITIONAL DIMENSIONS

This informative annex proposes approaches for extending TileMatrixSets and TileSet metadata for indexing and accessing 3D, 4D and n-D ($n > 2$) data as tiles, regardless of whether a simple file-based data store, a database (e.g. a GeoPackage) or a web API is used.

J.1. Extension approaches

All of these approaches assume that the multi-dimensional content spans the two dimensions defined by 2D TileMatrixSets, which are usually either latitude and longitude for geographic CRSes, or X/Easting or Y/Northing for projected CRSes, as well as other extra dimensions. The TileSet CRS can have more than two dimensions by re-using a common 2D TileMatrixSet but selecting a compatible CRS that includes additional dimensions, as specified in Clause 6.2.1.1.

J.1.1. No explicit tiling of extra dimensions

One way to extend the use of TileMatrixSet to support additional dimensions is to simply regroup all content falling within a 2D tile boundary of the TileMatrixSet together in the same tile, for the full extent of those additional dimensions. In other words, the additional dimensions are not tiled.

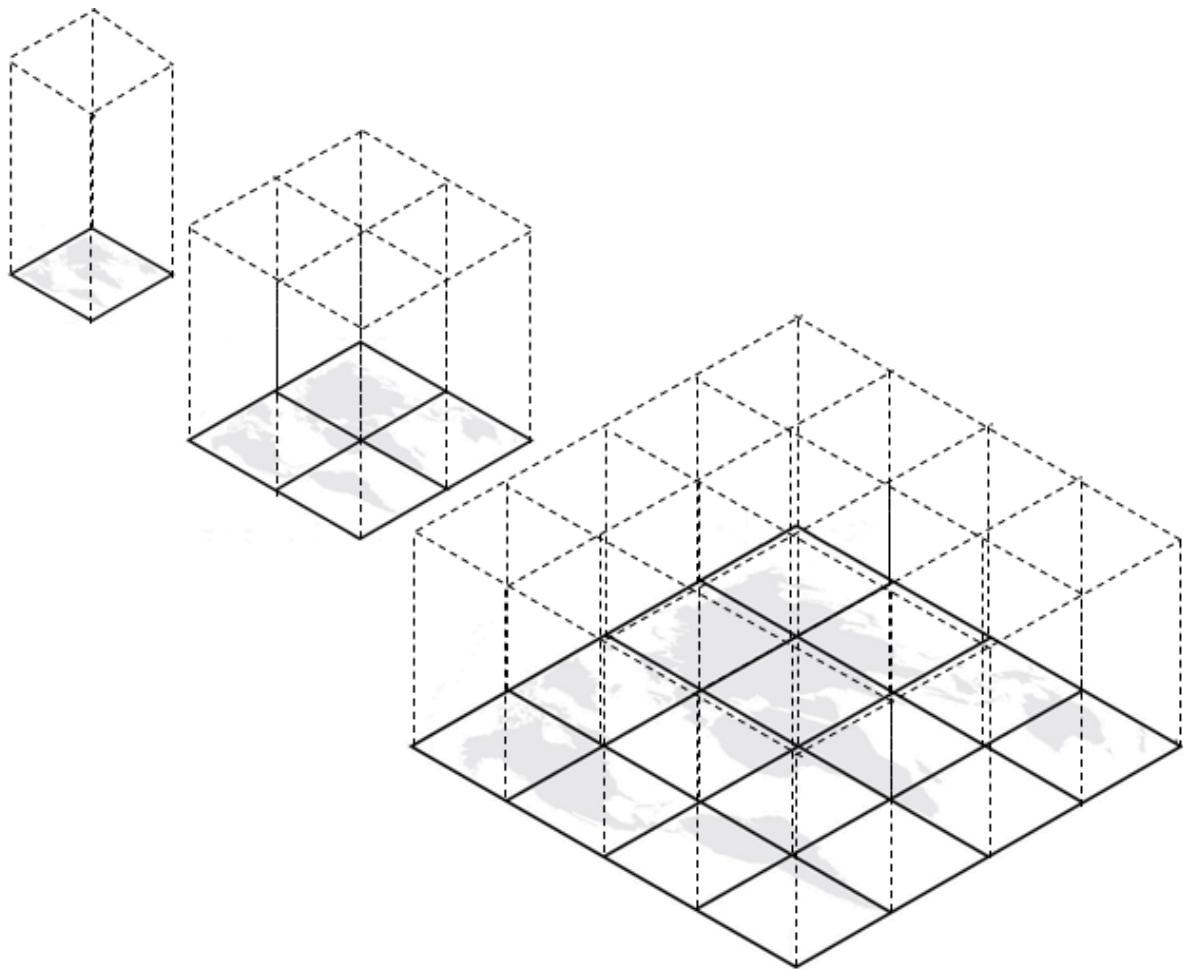


Figure J.1 – Extending TileMatrixSet vertically with no division

Storing, indexing and accessing the content for the additional dimensions can then be achieved through separate mechanisms, such as using formats supporting multiple dimensions (e.g. netCDF for coverages, glTF for 3D models, LAS for point clouds). Despite not being structured as tiles, extra dimensions could still be subset if the API supports a subsetting mechanism such as the subset (trimming or slicing) and datetime (temporal slicing) query parameters. Note that the data density or resolution of the extra dimensions can still be reduced for the lower resolution 2D tile matrices.

This approach is the only one supported by WMTS 1.0 where it is called “extra dimensions”, and it is also used in OGC CDB 1.x (see definition of the CDB Global Grid).

J.1.2. Same division for all tile matrices

Another approach is to also “tile” (divide) the extra dimension(s), but tile them in the same number of pieces for all n-D tile matrices.

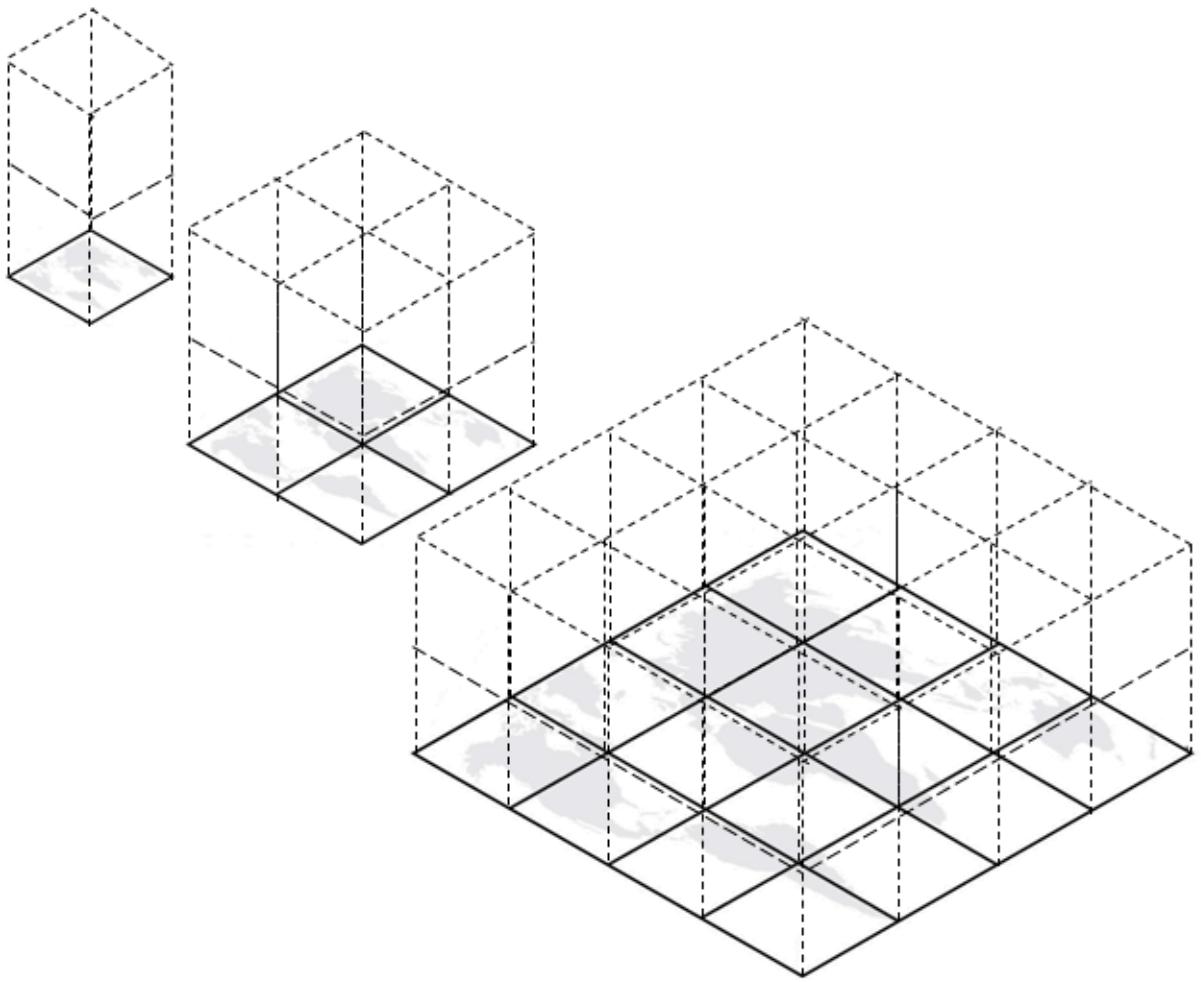


Figure J.2 – Extending TileMatrixSet vertically with the same tilings for all tile matrices (the illustration shows 2 "vertical" tile divisions for the extra "vertical" dimension for all tile matrices)

Fixed divisions for the extra dimensions may be suitable to scenarios where the extra dimensions have a limited extent, such as dividing all tile matrices by a small number of floors, by a few segments of altitudes, by month of the year or by a few years. Again, note that the data density or resolution of the extra dimensions can still be reduced for the lower resolution 2D tile matrices.

J.1.3. Octrees and Orthotrees (Hyperoctrees)

Finally, it might be beneficial to increase the number of tiles (divisions) for those additional dimensions for higher resolution tile matrices. Often, a 2D TileMatrixSet is built as a quad-tree, and a similar approach can be used with additional dimensions where it becomes an octree, or orthree for higher dimensions (orthant being the generalization of quadrants and octants), sometimes also called a *hyperoctree*.

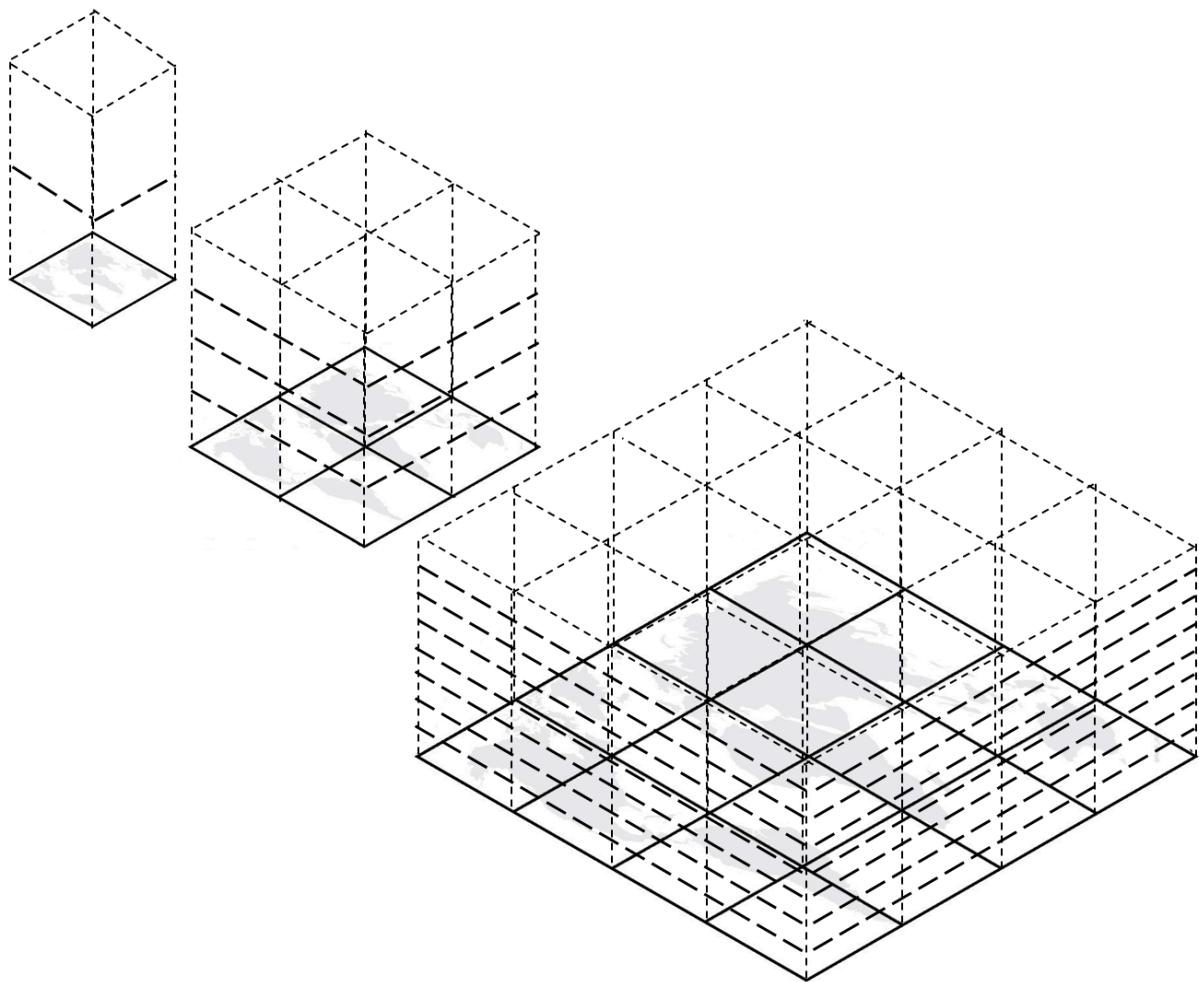


Figure J.3 – Extending TileMatrixSet vertically as an octree (The lowest resolution has 2 "vertical" tile divisions while the highest resolution has 8 "vertical" tile divisions)

J.2. Extended properties for TileMatrix & limits

An extraDimensions property can be added consisting of a list of identified (with dimension names) objects (associative array), each one with a description on how the additional dimensions are tiled. This information can be added to either a *TileMatrixSet*'s *TileMatrix* or to a *TileSet*'s *TileMatrixSetLimit*. Including this property in the *TileSet*'s *TileMatrixSetLimits* allows for the re-use of common 2D *TileMatrixSets*.

Table J.1 – Properties for an ExtraDimension data structure

| NAMES | DEFINITION | DATA TYPE AND VALUES | MULTIPLICITY AND USE |
|------------|-----------------------------------|----------------------|----------------------|
| identifier | Dimension identifier ^a | ows:CodeType | One (mandatory) |

| NAMES | DEFINITION | DATA TYPE AND VALUES | MULTIPLICITY AND USE |
|--------------------|--|-----------------------------|--|
| min | minimum value for that dimension (lower bound) | number | One (mandatory) |
| max | maximum value for that dimension (upper bound) | number | One (mandatory) |
| uom | unit of measure for defining min, max and resolution | string (URI) | One (mandatory) |
| divisions | in how many segments (trims in <i>Coverages</i> term) the space between min & max is divided at this particular tile matrix | positiveInteger | Zero or one (optional) Defaults to 1 if unspecified |
| resolution | resolution of the data in the extra dimension. For a coverage, this would be separate slices at that resolution interval, where the number of slices is equal to $(\text{max} - \text{min}) / \text{divisions} / \text{resolution}$, (+1 for point rather than area coverage). For 3D models, point clouds, vector features, the resolution would represent the average accuracy level at which you will find distinct coordinates. | number | Zero or one (optional) |
| temporalDivision | an alternative to <i>divisions</i> for temporal dimensions allowing to divide by unequal temporal units ^b | enumeration ^c | Zero or one (optional) |
| temporalResolution | an alternative to <i>resolution</i> for temporal dimensions allowing to specify a resolution | enumeration ^c | Zero or one (optional) |

| NAMES | DEFINITION | DATA TYPE AND VALUES | MULTIPLICITY AND USE |
|-------|--|----------------------|----------------------|
| | in unequal temporal units ^b | | |

^a These *ExtraDimension* identifiers SHALL be unique (different) within the context of the Tile MatrixSet.

^b Values other than the minimum and maximum may be used as discussed below.

^c The number of axes included, and the order of these axes, as specified by the referenced CRS.

J.2.1. Example TileMatrix extended to 4 dimensions (2 extra dimensions)

```
{
  "identifier" : "0",
  "scaleDenominator" : 139770566.0071794390678,
  "matrixWidth" : 4, "matrixHeight" : 2,
  "tileWidth" : 256, "tileHeight" : 256,
  "pointOfOrigin" : [ 90, -180 ],
  "extraDimensions" :
  {
    "elevation" : {
      "min" : -12000, "max" : 12000,
      "uom" : "http://www.opengis.net/def/uom/SI/metre",
      "divisions" : 2,
      "resolution" : 1000
    },
    "time" : {
      "min" : "2021-01-01", "max" : "2021-12-31",
      "uom" : "http://www.opengis.net/def/uom/ISO-8601/0/Gregorian",
      "divisions" : 1,
      "temporalDivision" : "year",
      "temporalResolution" : "month"
    }
  }
}
```

In this example the low-resolution overview tile matrix would feature $4 \times 2 \times 2 \times 1$ (16) tiles, each containing e.g. a 4+D coverage (a tile may contain additional dimensions beyond what is specified in the TileMatrixSet) with $256 \times 256 \times 12 \times 12$ values (equivalent to 144 regular 2D lat/lon slices or tiles).

This *extraDimensions* property supports any of the three approaches proposed above:

- The first approach (no explicit tiling of extra dimensions) does not strictly require this *extraDimensions* property, but may benefit from the ability to explicitly list the available dimensions and their extent, and to also specify a different *resolution* at each tile matrix.
- The second approach (same division for all tile matrices) is handled by specifying the same *divisions* value for all tile matrices. Note that the *resolution* may still differ.

- For the third approach (octrees and orthotrees), both the *divisions* and *resolution* properties would differ for each tile matrix.

J.3. Data contained in tiles

J.3.1. Vector Features

Many vector formats support geometry with an extra coordinate for the depth dimension to allow defining 3D geometry for simple features such as points, lines and polygons. Some formats may also explicitly support defining solids such as polyhedrons. Different approaches can be used to tile those features, e.g. picking one of the three aforementioned ways to divide (or not divide) those extra dimensions, and deciding whether to clip the features at tile boundaries (potentially marking artificial segments to facilitate reconstruction) or allow them to spill onto neighboring tiles so as to preserve the features whole. For formats that do not allow extra dimensions, properties that are not supposed to be spatial may contain coordinates (temporal).

J.3.2. Coverages

Coverage tiles can contain additional dimensions, which may or may not have gone through a trim operation. A precise subset operation corresponds to each of the three proposed approaches, which would also typically make use of a re-scaling (downsampling) operation as well to produce the lower resolution tiles.

J.3.3. Point Clouds

Point cloud data can be stored in tiles based on TileMatrixSets extended to 3D space, and thinned for lower resolution tile matrices. High-resolution point clouds would benefit from dividing the vertical dimension (using the second or third approach).

J.3.4. Point Features instantiating 3D models

One way to define 3D environments is to define 3D models in local 3D space and then instantiate them once or more by geo-referencing them and orienting them (i.e. defining a *GeoPose*). This can be accomplished by the use of point features and optional orientation and/or scaling property (which could either consist of a single or multiple values, e.g. only allowing yaw orientation or scaling all dimensions by the same factor, or also allowing to pitch and roll orientation, or separately scale the x, y and z dimensions). In CDB 1.x, this approach is used for both geo-typical as well as for geo-specific models.

It is especially suitable for shared geo-typical models which are defined only once and re-used many times, including in multiple tiles, for example to build forests re-using models of trees

while varying their sizes and orientations. Such models (and potentially their textures as well) would then need to be accessible separately from the tiling hierarchy. For example, vector tiles could be available as usual at, e.g.:

```
trees/tiles/GNOSISGlobalGrid/13/5200/5715.json  
trees/tiles/GNOSISGlobalGrid/13/5200/5715.mvt
```

while referencing shared 3D models, available at `models/{modelId}` and textures at `textures/{textureId}`, e.g.:

```
trees/models/coniferous_tree01.glb  
trees/models/coniferous_tree01.e3d  
trees/textures/1.jpg
```

A specific schema can be defined for position, orientation (e.g. yaw, pitch, roll), and scale (x, y, z), and a feature encoded as GeoJSON could look like:

```
{  
  "type" : "Feature",  
  "id" : 1175,  
  "geometry" :  
  {  
    "type" : "Point",  
    "coordinates" : [ -117.1577729394728, 32.8687124736055, 0 ]  
  },  
  "properties" :  
  {  
    "modelId" : "coniferous_tree01",  
    "modelScale" : [ 1.0, 0.8, 1.1 ],  
    "modelOrientation" : [ 323.0, 0, 0 ]  
  }  
}
```

The vertical position could either be relative to the terrain, to facilitate the use of different elevation models, or absolute coordinates in the CRS (e.g. relative to the WGS84 spheroid).

With this approach, only the points are clipped to the tile's boundary, while the models themselves may extend beyond. Techniques could be used to manage handling this scenario, such as still including the points from neighboring tiles spilling into the current tile, but flagging them as such.

J.3.5. Batched 3D Models

Another approach is to define a single 3D mesh batching all content within the tile. This approach is used by *3D Tiles* and *i3s* tilesets.

This could either clip the geometry exactly at the tile's boundary, or allow spilling onto the neighboring tiles, in which case information about the precise 3D bounding volume of the tile's content can come in handy.

Ideally, the mesh is defined with the center of the tile (e.g latitude, longitude and spheroid height) as the local origin, with the local axes lined up to the TileMatrixSet axes and the vertical axis orthogonal to them, and no separate geo-referencing or orientation information is required. This way, a tile from anywhere in the world opened in a 3D model viewer or editor would always have for example its buildings appear properly oriented upwards.

It is also useful to identify which portions of the mesh (e.g. triangles or faces) make up a particular features, e.g. the terrain, or a particular building, if supported by the 3D model format. The tiles batching 3D models can then follow the regular TileMatrixSet hierarchy. As an example the following paths could offer glTF, E3D and (3D Tiles) Batched 3D Model (consisting of glTF plus a header including e.g. a feature table) containing all buildings in a particular tile:

```
buildings/tiles/GNOSISGlobalGrid/13/5200/5715.glb  
buildings/tiles/GNOSISGlobalGrid/13/5200/5715.e3d  
buildings/tiles/GNOSISGlobalGrid/13/5200/5715.b3dm
```

J.4. Relationship with 3D Tiles and i3s

The 3D Tiles and i3s OGC community standards describe Bounding Volume Hierarchies (BVH) of 3D data. Those BVH tilesets allow dimensions of each tile to differ. While a TileMatrixSet can be used as the basis for producing 3D Tiles or i3s BVH tilesets, not all 3D Tiles or i3s tilesets need to be based on a TileMatrixSet.

When deciding on the use of a TileMatrixSet to define such tilesets, the space is partitioned exactly the same way, regardless of the content within that space. This has the advantage of allowing to deterministically access data for a particular portion of space from a fixed location irrespective of what or how much data may be contained in that space.

An alternative approach allowed by BVH is to distribute the data in tiles based on density, with the objective to balance the amount of data per tile, reducing the overhead of having many tiles where data is sparse, while avoiding a heavy load per tile in dense areas.

3D datasets based on a TileMatrixSet can be distributed as tiles just like 2D tilesets instead (or in addition to) as Bounding Volume Hierarchies (e.g. 3D Tiles and/or i3s), where the latter can simply reference the former (e.g. linking to .b3dm files organized in TileMatrixSet paths).



K

ANNEX K (INFORMATIVE) REVISION HISTORY

ANNEX K (INFORMATIVE) REVISION HISTORY

| DATE | RELEASED | AUTHOR | PARAGRAPH MODIFIED | DESCRIPTION |
|------------|----------|-----------|-----------------------|--|
| 2017-08-04 | v0.1 | Joan Maso | All | Initial draft |
| 2018-06-07 | v0.7 | Joan Maso | All | Document ready for the RFC period. http://www.opengeospatial.org/standards/requests/169 |
| 2019-02-07 | v0.14 | Joan Maso | All | Comments accepted introduced. Document sent to the TC for final approval |
| 2019-02-28 | v0.15 | Joan Maso | Section 4 and Annex D | Tiling scheme and tile set concept added. EPSG:32661 and 32662 replaced by EPSG:5041 and 5042 respectively |



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