Delivering Military Advantage through multi-national geospatial interoperability

DGIWG 126

DGIWG GeoPackage Profile

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Abstract:	This document is a profile of OGC 12-128r18, OGC GeoPackage Encoding Standard, Version 1.3.1, dated 2021-09-20. It defines specific Defence requirements, recommendations and guidelines for interoperability between producers and consumers of geospatial content in the GeoPackage file format for use by DGIWG member countries.
Copyright:	

Executive Summary

This profile of the Open Geospatial Consortium (OGC) GeoPackage standard enables DGIWG member nations producing and sharing geospatial raster and feature data to discover, understand, and utilize GeoPackages in a consistent interoperable format.

A GeoPackage is an open, standards-based, platform-independent, portable, self-describing, compact format used as a self-contained, run-time geospatial database and for transferring geospatial information. The OGC GeoPackage standard describes a set of conventions for storing the following within an SQLite database:

- Vector features
- Tile matrix sets of imagery and raster maps at various scales
- Extensions

To ensure this profile can be implemented, in order to distinguish between requirements, recommendations, and future work directions, the existing constraints identified by the submitting organizations and vendors have been taken into account. Requirements include both extensions/restrictions of the OGC GeoPackage standard as well as system requirements in order to enable interoperability by appropriately configuring existing software. System requirements are intended to be applied in the design of systems requiring services compliant with this profile. Requirements are associated with conformance tests which provide guidelines for testing the compliance of implementations of this profile.

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i. Contributing nations and organizations

Nation	Organization
Austria	Institute of Military Geography
France	Institut National de l'Information Géographique et Forestière (IGN)
Germany	Bundeswehr Geoinformation Centre (BGIC)
Sweden	Swedish Defence Materiel Administration
United Kingdom	Ministry of Defence (MOD)
United States	National Geospatial-Intelligence Agency (NGA)

ii. Document points of contact All questions regarding this document shall be directed to the editor (secretariat@dgiwg.org [mailto:secretariat@dgiwg.org]) or the contributor organizations.

iii. Revision history

Date	Release	Primary clauses modified	Description
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09/22/2023	1.0	Approved. Panel review updated to publish	For publication of 1.0

iv. Future Work

None defined.

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1 Introduction

This Interoperability Standard creates a Defence Geospatial-Information Working Group (DGIWG) profile based on the OGC GeoPackage based on the OGC GeoPackage Encoding Standard 1.3.1 ([4] OGC 12-128r18) in accordance with the provisions of Clause 2.5, Requirements 78-84, and Annex I, the abstract test suite for registered extensions of that Standard.

In this profile document, when the term "GeoPackage" is used without "OGC" or "DGIWG" preceding, the term refers to characteristics of the GeoPackage file and the content within the GeoPackage file that is applicable to all GeoPackage files.

This Interoperability Standard is a Class 2 conformance profile as defined by ISO 19106, Geographic Information – Profiles (dated 2004-07-01), that includes a single standard with permitted DGIWG extensions and restrictions to the standard. An Interoperability Standard provides detailed direction on how to use the clauses, options, and parameters of the base standard(s). An OGC GeoPackage is an open, standards-based, platform-independent, portable, self-describing, compact format for transferring geospatial information. The DGIWG GeoPackage standard profile describes a set of conventions for storing the following within an SQLite database:

- Vector features
- Tile matrix sets of imagery and raster maps at various scales
- Extensions to core functionality

The GeoPackage standard provides a configurable container that can be used to support several military use cases. The use cases range from discrete data bundles of operational information to support disadvantaged users, storing and dissemination of national or theater-level data to support large processing sites and servers, and support to autonomous data collection and retrieval operations. For each of these use cases, the core GeoPackage vector and raster content can be enhanced by a number of extensions to facilitate interoperability through standardizing tables and indexing information to include schema, tile matrix sets, styles, metadata, gridded coverage data (e.g., elevation data), and related non-spatial information (e.g., photos, audio files, sketches). This DGIWG profile provides direction on common means to leverage basic OGC GeoPackage capabilities as well as implementing extensions while maintaining interoperability.

A GeoPackage is stored as an SQLite container. The OGC and DGIWG GeoPackage Encoding Standards govern the rules and requirements of the content stored in a GeoPackage container. The OGC standard defines the schema for a GeoPackage, including table definitions, integrity assertions, format limitations, and content constraints. The required and supported content of a GeoPackage is entirely defined in the OGC standard. The DGIWG GeoPackage profile is written to clarify and constrain the implementation of OGC standard used by the DGIWG member nations.

As GeoPackage is a database container, it supports direct use. This means that data in a GeoPackage can be accessed and updated in a “native” storage format without intermediate

format translations. GeoPackages that comply with the requirements in the standard and do not implement vendor-specific extensions are more likely to be interoperable across all enterprise and personal computing environments. GeoPackages are particularly useful on mobile devices such as cell phones and tablets in communications environments where there is limited connectivity and bandwidth.

Software implementations that claim to be conformant with the DGIWG GeoPackage profile will support all mandatory operations, parameters, and elements of the base standard, as well as the specifically defined requirements in this document.

The framework, concepts, and methodology for testing, and the criteria to be achieved to claim conformance to the underlying OGC GeoPackage specification are summarized in the OGC Compliance Testing Policies and Procedures on the OGC Compliance Testing website.

2 Scope

This document defines specific DGIWG requirements, recommendations, and guidelines for implementations of the OGC GeoPackage Encoding Standard 1.3.1 [4] OGC 12-128r18. This interoperability standard defines DGIWG implementable provisions that profile the OGC GeoPackage standard to ensure that DGIWG GeoPackages, GeoPackage SQLite Extensions, and supporting utilities and services fulfill their intended purposes and are fit for use.

The DGIWG GeoPackage profile is intended to be used by government, commercial, open-source development, and Non-Governmental Organizations (NGOs) in the following ways:

- Data Providers deliver DGIWG GeoPackage data files. These applications may be stand-alone application or embedded within larger applications or environments.
- Infrastructure Software Providers deliver software that implements the SQLite engine, GeoPackage SQLite Extensions, GeoPackage libraries, and/or stand-alone GeoPackage utilities or web services to encode/decode, validate, and manage GeoPackage files.
- Application Software Providers deliver GeoPackage “Apps” that provide users with the capabilities they require in general or mission-specific environments. They may employ software provided by Infrastructure Providers and bundle their Apps with GeoPackages from Data Providers.
- Defence Procurement Organizations that acquire DGIWG conformant GeoPackages, infrastructure, and applications.

System architects, software engineers, developers, and data modelers of the DGIWG member organizations and its component systems/applications in the roles listed above aim to promote uniform geospatial data access, GeoPackage and GeoPackage SQLite Extension development and use. The goal is to increase interoperability, modularity, and agility of applications within coalition architectures. This Profile is an adjunct to the base OGC GeoPackage standard – not a stand-alone document.

Coalition operations and multinational cooperation require interoperable approaches to GeoPackage production and exchange, in order to make sharing of raster and vector data possible. As the OGC GeoPackage specification itself does not provide sufficient guidance to enable interoperability in the coalition, this DGIWG profile provides requirements and recommendations to improve the interoperable use of GeoPackage files in the following areas:

- Define common components to include Coordinate Reference Systems (CRS), metadata, and tilesets structure.
- Identify common GeoPackage capabilities for vector datasets and raster.
- Address use cases.
- Address optional use of specific extensions most appropriate to DGIWG applications.

3 Conformance

The GeoPackage profile is defined in terms of the Normative Requirements in section 6.1. These requirements compose the Conformance Classes in section 3.1. Associated with a requirement, each conformance class is the basis for the abstract test cases in Annex A, which are used to define tests to measure an implementation's conformance to the DGIWG profile of GeoPackage.

3.1 Conformance classes

This document establishes eight conformance classes in two sets:

Table 1: Conformance Classes

Class #	Class Name	Class Identifier	ATS
		OGC GeoPackage	
1	geopackage	http://www.dgiwg.org/std/gpkg/1.0/conf/geopackage	ATS A.1
		DGIWG GeoPackage Profile	
2	extensions	http://www.dgiwg.org/std/gpkg/1.0/conf/extensions	ATS A.2
3	crs	http://www.dgiwg.org/std/gpkg/1.0/conf/crs	ATS A.3
4	metadata	http://www.dgiwg.org/std/gpkg/1.0/conf/metadata	ATS A.4
5	validity	http://www.dgiwg.org/std/gpkg/1.0/conf/validity	ATS A.5
6	tile	http://www.dgiwg.org/std/gpkg/1.0/conf/tile	ATS A.6
7	zoom	http://www.dgiwg.org/std/gpkg/1.0/conf/zoom	ATS A.7
8	bbox	http://www.dgiwg.org/std/gpkg/1.0/conf/bbox	ATS A.8

The conformance classes and requirements for OGC GeoPackage are contained in the referenced OGC specification. The OGC GeoPackage class includes both conformance classes in the OGC specification: Core (base) and Optional (options).

A DGIWG profile of GeoPackage must conform to both the OGC and DGIWG conformance class listed in Table 1. Any optional requirements in a DGIWG compliant GeoPackage must conform to the Options OGC conformance class. Additional options and restrictions of the OGC conformance classes are stated in the DGIWG GeoPackage profile conformance classes.

DGIWG GeoPackage (GPKG) Profile conformance classes select requirements for GeoPackage

producers and consumers allowing distribution of geospatial data in a military environment. The requirements in the conformance classes are contained within the sections of this document. Annex A lists the conformance abstract tests referencing requirements which will be exercised on any GeoPackage file claiming to implement the DGIWG GeoPackage profile.

NOTE

"http://www.dgiwg.org/std/gpkg/1.0/conf/<class>" is an HTTP URI which works as an identifier for the DGIWG conformance class. It is not an URL, redirecting to a web page. 1.0 identifies the version of the DGIWG standard (not the version of GPKG it profiles).

4 Normative and Informative References

Normative (prescriptive) references in the DGIWG GeoPackage Interoperability Standard are identified in Table-2. Normative references include provisions that are directly referenced in the DGIWG GeoPackage profile.

Table 2: Normative References in DGIWG GeoPackage Interoperability Standard

#	Title	Reference	Version
[1]	DGIWG Metadata Foundation (DMF)	DGIWG - 114. Geospatial metadata profile for the military community, based on ISO 19115, ISO 19115-1 and ISO 19115-2	Ed.2.0 12 July 2017
[2]	EPSG Geodetic Parameter Registry Version: 8.6.1	The EPSG Geodetic Parameter Dataset is a structured dataset of Coordinate Reference Systems and Coordinate Transformations, accessible through this online registry (www.epsg-registry.org) or, as a downloadable zip file, through OGP's EPSG home page at www.epsg.org. The geographic coverage of the data is worldwide, but it is stressed that the dataset does not and cannot record all possible geodetic parameters in use around the world. The EPSG Geodetic Parameter Dataset is maintained by the Geodesy Subcommittee of OGP's Geomatics Committee	v8.6.1
[3]	OGC 06-103r4, OpenGIS® Implementation Standard for Geographic information - Simple feature access - Part 1: Common architecture	Revised OGC Simple Features specification – common architecture	v1.2.1, 28 May 2011
[4]	OGC 12-128r18, OGC GeoPackage Encoding Standard	This OGC® Encoding Standard defines GeoPackages for exchange and GeoPackage SQLite Extensions for direct use of vector geospatial features and / or tile matrix sets of earth images and raster maps at various scales	v1.3.1, 09-20-2021
[5]	OGC 17-066r2, OGC GeoPackage Extension for Tiled Gridded Coverage Data	The "GeoPackage Extension for Tiled Gridded Coverage Data" extension (previously titled Elevation Extension) defines how to encode and store tiled regular gridded data, such as a digital elevation model, in a GeoPackage	v1.1, 02-May-2022

#	Title	Reference	Version
[6]	OGC 17-083r2,- OGC Two Dimensional Tile Matrix Set	The OGC Tile Matrix Set 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: Spatial Referencing by Coordinates	v1.0, 06 Oct 2019
[7]	OGC 18-000, OGC GeoPackage Related Tables Extension (RTE)	This document defines the Related Tables Extension (RTE) for the GeoPackage Encoding Standard. The RTE defines the rules and requirements for creating relationships in a GeoPackage data store between geospatial data tables and other tables that contain or reference related content such as attributes or media	v1.0, 08 May 2019
[8]	OGC 12-063r5, WKT1 - Standard: Geographic information - Well-known text representation of coordinate reference systems	Provides an updated version of WKT representation of coordinate reference systems that follows the provisions of ISO 19111:2007 and ISO 19111-2:2009. It extends the earlier WKT to allow for the description of coordinate operations.	v1.0, 01 May 2015
[9]	OpenGIS Project Document 01-009, OpenGIS® Implementation Specification: Coordinate Transformation Services	The OpenGIS® Coordinate Transformation Service Standard (CT) provides a standard way for software to specify and access coordinate transformation services for use on specified spatial data. This standard addresses a key requirement for overlaying views of geodata (“maps”) from diverse sources: the ability to perform coordinate transformation in such a way that all spatial data are defined relative to the same spatial reference system	v1.0, 12 Jan 2001

The documents listed in Table-3 contain useful information to augment DGIWG understanding and application of the material in this interoperability standard in conjunction with the actual standard profiled.

Table 3: Informative References in DGIWG GeoPackage Interoperability Standard

Reference Identifier	Standards and Specifications Title
CJCSI 3900.01D, 14 May 2015	Position (Point and Area) Reference Procedures
DES.ISM.XML, v13, 09 May 2014	XML Data Encoding Specification for Information Security Markings - This XML Data Encoding Specification for Information Security Markings (ISM.XML) defines detailed implementation guidance for using Extensible Markup Language (XML) to encode Information Security Markings (ISM) data. This Data Encoding Specification (DES) defines the XML elements and attributes, associated structures and relationships, mandatory and cardinality requirements, and permissible values for representing security marking concepts using XML
EPSG Guidance Note 373-07-1	Surveying and Positioning Guidance Note Number 7, part 1, clause 5.9 EPSG codes and names
GeoPackage Community Extensions	Not official extensions to the GeoPackage Encoding Standard. These extensions may be developed as part of OGC Innovation Program activities or completely outside of OGC activities. Using a community extension (even if it is proprietary) may be preferable to developing your own extension. See www.geopackage.org/extensions.html .
IETF RFC 2119, S. Bradner, Harvard University, March 1997	Key Words for use in RFCs to Indicate Requirement Levels
ISO/IEC 13249-3:2016, Ed. 5, 2016	Information technology — Database languages — SQL multimedia and application packages — Part 3: Spatial - The purpose of ISO/IEC 13249 is to define multimedia and application specific types and their associated routines using the user-defined features in ISO/IEC 9075
ISO/TS 19101-1:2014	Geographic Information – Reference Model - Part 1: Fundamentals
ISO/TS 19101-2:2018	Geographic Information – Reference Model - Part 2: Imagery
ISO 19106:2004(E)	Geographic information – Profiles
ISO 19111:2019	Geographic information – Referencing by coordinates
ISO 19112:2019	Geographic information – Spatial referencing by geographic identifiers
ISO 19162:2019	Geographic information – Well-known text representation of coordinate reference systems

Reference Identifier	Standards and Specifications Title
NATO AGeoP-21 Ed A Ver 1, February 2016	Geodetic Datums, Projections, Grids and Grid References - Establish the U.S. Department of Defense World Geodetic System 1984 (WGS 84) as the standard geodetic system for geospatial information used by NATO. The document also defines how datums, coordinates, projections, grids and position reporting are to be applied to geospatial information and used by NATO
NGA.SIG.0012_2.0.0_UTMUPS v2.0, 25 March 2014	This document defines the UTM, UPS and MGRS systems of coordinates and their implementation
NGA.SIG.0014_1.0_PROJRAS V1.0, 24 April 2015	Specifies the map projections that should be used when implementing OGC GeoPackage Encoding Standard, OGC 12-128r10
NGA.SIG.0028_1.0.0_MAPPROJ v1.0, 13 Dec 2017	Map Projections for GEOINT Content, Products, and Applications
NGA.STND.0012_3.0, v3.0, 31 August 2016	The U.S. National System for Geospatial Intelligence (NSG) Metadata Foundation (NMF) defines the minimum mandatory geospatial metadata for datasets, series, and services in the NSG.
NGA.STND.0018_3.0, version 3.0, 20 January 2017	The U.S. National System for Geospatial Intelligence (NSG) Metadata Implementation Specification (NMIS) v3.0 specifies an Extensible Markup Language (XML) encoding of the NSG Metadata Foundation (NMF) v3.0 conformant to ISO 19115-3:2016
NGA.STND.0019_2.0.1, 20 Aug 2020	NGA Standardization Document + Time-Space-Position Information (TSPI)
NGA.STND.0037_2.0.0_GRIDS, v2.0.0, 28 February 2014	Universal Grids and Grid Reference Systems - intended for use when developing systems that generate map grids and grid data for portrayal on products, and to ensure their correctness on such products; and for the development of doctrine for land navigation and location referencing. This standard is referenced in NATO documents, and is necessary for interoperability with DoD international partners and allies
OGC 06-104r4, v1.2.1, 04 Aug 2010	OpenGIS® Implementation Standard for Geographic information — Simple feature access — Part 2: SQL option - Revised OGC Simple Features specification – SQL encoding
OGC 10-100r3, v3.2.1	Geography Markup Language (GML) simple features profile (with technical note) - GML Simple Features Profile that specifies restricted subset of simple geometry types
OGC 18-005r5, v5.0.01, 2021-07-02	OGC Abstract Specification Topic 2: Referencing by coordinates Corrigendum - defines the conceptual schema for the description of referencing by coordinates consistent with ISO 19111:2019.

Reference Identifier	Standards and Specifications Title
OGC 18-010r7, v2.0.6, 03 Aug 2019	OpenGIS® Standard: Geographic information (WKT2) - Well-known text representation of coordinate reference systems. Provides an updated version of WKT representation of coordinate reference systems that follows the provisions of ISO 19111:2019. It extends the WKT in OGC document 12-063r5 [8], (ISO 19162).
OGC 13-082r2 v1.0, 19 Jan 2016	OGC® Web Map Tile Service (WMTS) Simple Profile
OGC 99-049, Rev.1.1, 5 May 1999	OpenGIS® Simple Features Specification for SQL - Original OGC SF/SQL specification

5 Terms, definitions, and abbreviations

Definitions

The purposes of this document, terms, and definitions found in the DGIWG GeoPackage Profile apply.

Table 4: Terms and Definitions

aspatial support	Support for aspatial data (i.e. SQLite tables/views without a geometry column), potentially with associated metadata.
community extension	GeoPackage extensions that are not officially approved extensions to the OGC GeoPackage Encoding Standard. These extensions may be developed as part of OGC Innovation Program activities or completely outside of OGC activities. Using a community extension (even if it is proprietary) may be preferable to developing your extension. Extensions that have widespread adoption may be considered for OGC approval.
compound coordinate reference system	A compound coordinate reference system is a non-repeating sequence of two or more coordinate reference systems none of which can itself be compound. (OGC 18-005r5). The compound A coordinate reference system for GeoPackage uses two other independent coordinate reference systems, one for the horizontal component and one for the vertical component, to describe a position (derived from INSPIRE Glossary).
conformal mapping	Conformal mapping, also called a conformal map, conformal transformation, angle-preserving transformation, or biholomorphic map, is a transformation that preserves local angles. An analytic function is conformal at any point where it has a nonzero derivative. Conversely, any conformal mapping of a complex variable that has continuous partial derivatives is analytic. Conformal mapping is extremely important in complex analysis, as well as in many areas of physics and engineering.
coordinate reference system	A coordinate system that is related to an object by a datum. [OGC 18-005r5]
coordinate system	A set of mathematical rules for specifying how coordinates are to be assigned to points. [OGC 18-005r5]

coverage	A coverage is a function that describe characteristics of real-world phenomena that vary over space and/or time. Typical examples are temperature, elevation and precipitation. A coverage is typically represented as a data structure containing a set of such values, each associated with one of the elements in a spatial, temporal or spatiotemporal domain. Typical spatial domains are point sets (e.g. sensor locations), curve sets (e.g. contour lines), grids (e.g. orthoimages, elevation models), etc. A property whose value varies as a function of time may be represented as a temporal coverage or time-series. [OGC 17-066r2]
data validity constraints	Constraints on allowable data values in GeoPackage SQL tables to enable assessment and enforcement of data validity. Its requirements are conditional based on whether a GeoPackage contains features or tiles.
datum	A datum (in modern geodesy, a reference frame) specifies the relationship of a coordinate system to an object, thus ensuring that the abstract mathematical concept “coordinate system” can be applied to the practical problem of describing positions of features by means of coordinates. The object will generally, but not necessarily, be the Earth or a feature on the Earth such as a building. [OGC 18-005r5]
disadvantaged user	Persons using information technology in an environment that lacks access to or has a low level of network bandwidth and/or computing capacity.
gridded data	Data whose attribute values are associated with positions on a grid coordinate system 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.
informative metadata reference	A citation to any information resources used to compile the metadata and construct the metadata record. Each Metadata Source Reference takes the form of a citation.
Infrastructure Providers	The underlying operating system and common services that provide a platform to host the applications used to create and utilize the GeoPackage format.
interoperability	Capability to communicate, execute programs, or transfer data among various functional units in a manner that requires the user to have little or no knowledge of the unique characteristics of those units ISO 2382-1. "The ability for a system or components of a system to provide information portability and inter-application, cooperative process control. Interoperability, in the context of the OpenGIS Specification, is software components operating reciprocally (working with each other) to overcome tedious batch conversion tasks, import/export obstacles, and distributed resource access barriers imposed by heterogeneous processing environments and heterogeneous data.

map projection	A set of mathematical algorithms and associated parameters that establish a systematic, one-to-one correspondence between points on the surface of an ellipsoid and points on a plane while controlling the resulting geometric distortions. (NGA.SIG.0028)
navigation	A recommended use of geospatial data that indicates whether the map projection can be used for land, sea, and air navigation provided that its sources, content, scale, and usage adhere to the Navigation doctrine. [NGA.SIG.0028_1.0.0_MAPPROJ]
OGC compliance and interoperability testing and evaluation program	The OGC Conformance & Interoperability Testing & Evaluation Initiative (CITE) is an OGC Interoperability Initiative designed to test and evaluate OGC Interfaces and products that implement them. The CITE Initiative has three focus areas related to the establishment of a successful and robust OGC Conformance and Interoperability Test and Evaluation Program: Planning and Feasibility Study, Conformance Engine, Scripts and Guidelines, and CITE Portal and Reference Implementations.
OGC web services context	The OGC Web Services Context Document (OWS Context) was created to allow a set of configured information resources (service set) to be passed between applications primarily as a collection of services. OWS Context is developed to support in-line content as well. The goal is to support use cases such as the distribution of search results, the exchange of a set of resources such as OGC Web Feature Service (WFS), Web Map Service (WMS), Web Map Tile Service (WMTS), Web Coverage Service (WCS) and others in a 'common operating picture'.
raster map	Numeric representation of a cartographic map that may represent differing features of an area, such as a topographic map, navigation chart, or general reference product; these are either replicas of graphic products that are scanned, or a representation of an equivalent topographic vector product at an equivalent scale, according to a sampling resolution. [DGIWG 254]
raster tile pyramid	Pyramids are used to improve performance. They are a downsampled version of the original raster dataset and can contain many downsampled layers. Each successive layer of the pyramid is downsampled at a scale of 2:1.
Related Tables	The Related Tables extension (OGC 18-000) defines the rules and requirements for creating relationships in a GeoPackage datastore between geospatial or attributes data tables and other tables that contain or reference related content such as attributes or media. Geospatial data tables (such as features or tiles tables) contain location information and/or geometries. Conceptually, this extension is similar to the OGC Table Joining Service Interface Standard. [OGC TJS-IS, 10-070r2]
relative positioning	A recommended use of geospatial data that indicates whether data (i.e. map projection) can be used for relative positioning, i.e. the determination of the coordinates of a point by applying range and bearing measurements relative to a point whose coordinates are known.

RTree spatial indexes	The RTree Spatial Indexes extension provides a means to encode an RTree index for geometry values in a GeoPackage. An RTree index provides a significant performance advantage for searches with basic envelope spatial criteria that return subsets of the rows in a feature table with a non-trivial number (thousands or more) of rows.
semantic annotations	The process of attaching additional information to various concepts (e.g., people, things, places, organizations, etc.) in a given text or any other content. Unlike classic text annotations for the reader's reference, semantic annotations are used by machines to refer.
spatial reference system	A Spatial Reference System is a superset which includes a Coordinate Reference System (CRS) and spatial referencing by geographic identifier. But in ISO 19125-1 only CRS concepts are described.
spatiotemporal reference system	A Spatial Reference System with a temporal dimension, i.e. time.
SQLite	SQLite is a C-language library that implements a small, fast, self-contained, high-reliability, full-featured, SQL Relational database engine.
SQL triggers	In a SQL database, triggers are database objects, a special kind of stored procedure, which "reacts" to certain actions we make in the database. The main idea behind triggers is that they always perform an action in case some event happens.
tile matrix set	The OGC Tile Matrix Set 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 08-015r2] Abstract Specification Topic 2: Spatial Referencing by Coordinates.
vector	A representation of the spatial extent of geographic features using geometric elements (such as point, curve, and surface) in coordinate space.
Web map server	a standard protocol developed by the OGC in 1999 for serving georeferenced map images over the Internet. These images are typically produced by a map server from data provided by a GIS database.
Web services	Web services are self-contained, self-describing, modular applications that can be published, located, and invoked across the Web. Web services perform functions that can be anything from simple requests to complicated business processes. Once a Web service is deployed, other applications (and other Web services) can discover and invoke the deployed service.
WebP	An image format that uses either (i) the VP8 key frame encoding to compress image data in a lossy way, or (ii) the WebP lossless encoding (and possibly other encodings in the future). These encoding schemes should make it more efficient than currently used formats.

well-known text	Well-known text (WKT) offers a compact machine- and human-readable representation of geometric objects. WKT may also be used for succinctly describing the critical elements of coordinate reference system (CRS) definitions.

Abbreviations

Table 5: Abbreviations

3D	3 Dimensional
AGC	Army Geospatial Center
COP	Common Operational Picture
CRS	Coordinate Reference Systems
CT	Coordinate Transformation Service Standard
COMP	Compound CRS type
DES ISM XML	XML Data Encoding Specification for Information Security Markings
DGED	Defence Gridded Elevation Data
DGIWG	Defence Geospatial Information Working Group
DMF	DGIWG Metadata Foundation
DoD	Department of Defense
DSE	Data Services Environment
DTED	Digital Terrain Elevation Data
EGM	Earth Gravitational Model
EPSG	European Petroleum Survey Group
ETRS89	The European Terrestrial Reference System 1989
GDAL	Geospatial Data Abstraction Library
GEOD	Geodetic CRS type
GeoJSON	Geographic JavaScript Object Notation
GML	Geography Markup Language
Gpkg	GeoPackage
GPS	The Global Positioning System
IC	Intelligence Community
IEC	International Electrotechnical Commission
IETF RFC	Internet Engineering Task Force Requests for Comments
IR	Information Resources

ISO	International Organization for Standardization
LAEA	Lambert azimuthal equal-area projection
LCC	Lambert Conformal Conic
MGCP	Multi-national Geospatial Co-production Program
MGRS	The Military Grid Reference System
MIME	Multipurpose Internet Mail Extensions
MSL	Mean Sea Level
NAD83	The North American Datum of 1983
NATO	The North Atlantic Treaty Organization
NGA SIG	NGA Standardization Information Guidance
NGOs	Non-Governmental Organizations
NMF	NSG Metadata Foundation
NMIS	NSG Metadata Implementation Specification
NSG	The National System for Geospatial Intelligence
OGC	Open Geospatial Consortium
OGC CITE	OGC Compliance and Interoperability Testing and Evaluation Program
OGC SF	OGC Simple Features
OGL	Open Government Licence
OGP	Open Government Partnership
OWS	OGC Web Services
QGIS	Quantum Geographic Information System
PROJ	Projected CRS type
RTE	Related Tables Extension
SME	subject matter expert
SQL	Structured Query Language
SRS	Spatial Reference Systems
TC	Technical Committee
TMS	tiles matrix sets
TSPI	Time-Space-Position Information
UPS	Universal Polar Stereographic
URI	Uniform Resource Identifier
UTM	Universal Transverse Mercator
VERT	Vertical CRS type

WGS 84	World Geodetic System of 1984
WKSS	Well-Known Scale Sets
WKT	Well-Known Text
WKT1	Well-Known Text version 1
WKT2	Well-Known Text version 2
XML	Extensible Markup Language

DGIWG GeoPackage Profile

A GeoPackage that complies with the DGIWG GeoPackage profile will:

a) satisfy all requirements stipulated in the OGC GeoPackage Encoding Standard 1.3.1;

b) satisfy all requirements stipulated in this document.

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

Note: All Requirements and Recommendations presented within this document is the result of information gathered from DGIWG Nations participating in the DGIWG Web Services Technical Panel, GeoPackage experiments and the profile development process. Implementers should be aware that certain requirements are unique to a national profile and recognize that organizations may need to utilize different configurations to meet specific operational or nationally directed requirements, especially concerning projections and metadata. DGIWG recommends that in these cases, general adherence with the guidance of this profile is maintained with only essential national modifications.

6 GeoPackages

6.1 Normative Requirements

This chapter defines normative requirements to implement the DGIWG GeoPackage conformance class. Specific conformance classes are defined in section 3.0 and tested for compliance in Annex A.

The first two requirements ensure compliance to the GeoPackage Encoding Standard.

Requirement 1	/req/geopackage/base ***The DGIWG GeoPackage SHALL comply with all the OGC GeoPackage standard requirements in the Base conformance class according to the normative reference [4] GeoPackage Encoding Standard and the requirements defined therein in any GeoPackage that contains the extensions used in this GeoPackage.***

Requirement 2	/req/geopackage/options ***The DGIWG GeoPackage SHALL comply with all the OGC GeoPackage standard requirements in the Options conformance class according to the normative reference [4] GeoPackage Encoding Standard and the requirements defined therein.***

The Normative requirements requested by this conformance class are summarized in Table-6.

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

- Mandatory (M) – The requirement must be implemented
- Conditional (C) – Mandatory when “If” statement applies

For the DGIWG profile, a Mandatory requirement states a capability that must be present in GeoPackage data produced by DGIWG member countries and GeoPackages used by DGIWG members in a coalition environment. The Conditional requirements in the DGIWG GeoPackage profile apply if the implementation or use of GeoPackage meets a specific condition. Each requirement has a unique identifier listed in Table-6. The Identifier for each Requirement is abbreviated in this document. According to best practices in the DGIWG namespace structure and management, the full identifier for each requirement in the DGIWG GeoPackage profile version 1.0 is www.dgiwg.org/std/gpkg/1.0/req/<identifier> . Following OGC structured requirements, the requirements in this document are reference by a hyperlink to the name or the Requirement Identifier. The requirement number is provided for convenience, and may change in revisions to the profile.

Table 6: Normative Requirements

No.	Requirement Name	Identifier	Compliance
1	GeoPackage Base definition	/req/geopackage/base	M
2	GeoPackage Options definition	/req/geopackage/options	M
3	Mandatory Extensions	/req/extensions/mandatory	M
4	Optional Extensions	/req/extensions/optional	C
5	Extensions Not Allowed	/req/extensions/not-allowed	M
6	Conditional Extensions	/req/extensions/conditional	C
7	Raster CRS Allowed	/req/crs/raster-allowed	M
8	CRS Raster tile matrix set	/req/crs/raster-tile-matrix-set	M
9	Two-Dimensional Vector CRS	/req/crs/2d-vector	M
10	Three-Dimensional Vector CRS	/req/crs/3d-vector	M
11	Well Known Text for CRS	/req/crs/wkt	M
12	Compound CRS Usage	/req/crs/compound	C
13	Compound CRS Well Known Text	/req/crs/compound-wkt	M
14	GeoPackage Metadata DMF	/req/metadata/dmf	M
15	GeoPackage Metadata document	/req/metadata/gpkg	M
16	Complete Row GeoPackage Metadata	/req/metadata/row	M
17	User Row GeoPackage Metadata	/req/metadata/user	C
18	GeoPackage Product Metadata	/req/metadata/product	C
19	GeoPackage Product Partial Metadata	/req/metadata/product-partial	C
20	GeoPackage Data Validity	/req/validity/data-validity	M
21	Tile Matrix Width Height	/req/tile/size-matrix	M
22	Tile Pyramid Data Width Height	/req/tile/size-data	M

No.	Requirement Name	Identifier	Compliance
23	Zoom level factor	/req/zoom/factor	M
24	Tile Matrix Set with Multiple Zoom Levels	/req/zoom/matrix-sets-multiple	C
25	Tile Matrix Set with one Zoom Level	/req/zoom/matrix-sets-one	C
26	Tile Matrix Set CRS Bounding box	/req/bbox/crs	M
27	Tile layer Metadata	/req/metadata/tile	C
28	Feature layer Metadata	/req/metadata/feature	C

6.2 Recommendations

This chapter defines informative recommendations that guide the implementation of the DGIWG GeoPackage profile. Recommendations have an identifier, but are not bound to conformance classes.

The Recommendations defined by this profile are summarized in Table-7.

Table 7: Recommendations

No.	Recommendation	Identifier
1	GeoPackage Product Metadata	/recco/metadata-product

6.3 Extensions

GeoPackage Extensions add or modify the SQL tables within a GeoPackage. Some extensions are not defined in the GeoPackage core specification, but in documents separate from the OGC GeoPackage Encoding Standard. All extensions are registered in the gpkg_extension table.

The extensions from OGC GeoPackage 1.3, other OGC published extensions, and community extensions are considered for the DGIWG Profile. Table-8 indicates those approved OGC GeoPackage extension that are mandatory/required (M), optional/recommended (O), conditional (C), not allowed (N) or not applicable (NA) to the DGIWG Profile. In the OGC document, details on the use of the extensions are addressed in section 2.3 for tiles and features. The deprecated extensions are not listed.

Table 8: Normative Extensions

Extension	**Name**	**Source**	**DGIWG Profile: O – Optional, M – Mandatory, N - Not Allowed, C - Conditional, NA - Not Applicable**	
			Features	**Tiles**
F.1 GeoPackage Nonlinear Geometry Types	gpkg_geom_	[4] OGC GPKG 1.3.1	N	NA
F.3 RTree Spatial Indexes	gpkg_rtree_index	[4] OGC GPKG 1.3.1	M	NA
F.6 Zoom other Intervals	gpkg_zoom_other	[4] OGC GPKG 1.3.1	NA	N
F.7 File Encoding WebP	gpkg_webp	[4] OGC GPKG 1.3.1	NA	N
F.8 Metadata	gpkg_metadata	[4] OGC GPKG 1.3.1	M	M
F.9 Schema	gpkg_schema	[4] OGC GPKG 1.3.1	O	O
F.10 WKT for CRS	gpkg_crs_wkt	[4] OGC GPKG 1.3.1	M	M
F.11 Tiles Gridded Coverage	gpkg_2d_gridded_coverage	[5] OGC 17-066r2	NA	O
F.12 Related Tables	related_tables	[7] OGC 18-000	O	O

Extensions F.2, F.4, and F.5 have been removed from the OGC GeoPackage specification and are not listed in Table-8. Conformance of GeoPackage extensions is enforced by the following four

requirements associated with the compliance of GeoPackages containing features and tiles as listed in Table-8.

Requirement 3	/req/extensions/mandatory ***GeoPackages containing Feature and/or Tile data SHALL be implemented to contain ALL of the Mandatory (M) GeoPackage extensions in Table-8.***
Requirement 4	/req/extension/optional ***GeoPackages containing Feature and/or Tile data SHALL be implemented to use any number of the Optional (O) GeoPackage extensions in Table-8 applicable to the data type Features and/or Tiles.***
Requirement 5	/req/extensions/not-allowed ***GeoPackages containing Feature and/or Tile data SHALL be implemented to contain NONE of the Not Allowed (N) GeoPackage extensions in Table-8.***
Requirement 6	/req/extensions/conditional ***GeoPackages containing Feature and/or Tile data SHALL be implemented to use any of the Conditional (C) GeoPackage extensions in Table-8 where the conditional criteria of the extension is true.***

When an extension is Not Allowed (“N”) for feature data or tile matrix sets in Table-8 of this profile and DGIWG in the future has a need to use that extension, the DGIWG community has an option to either modify this profile to allow the extension or to create a DGIWG profile of the extension to specify the community use of a specific GeoPackage extension. Once DGIWG approves a distinct profile of a GeoPackage extension, compliance to the extension profile’s requirements take precedence over compliance to requirements for the same extension as specified in this DGIWG

profile, DGIWG 126.

This profile accommodates additional extensions, whether an OGC extension or developmental extension that lacks a conformance requirement. Community extensions are not normative until they have been approved by OGC. Future consideration may promote a Community extension to become an approved extension that is incorporated into the OGC GeoPackage specification or a separate specification. Implementations of non-conformant extensions should recognize that changes or revisions are likely as the extension matures in the standards development process. The GeoPackage Community Extensions are published at https://www.geopackage.org/extensions.html .

OGC Standard extensions and Community extensions not contained in Table-8 are allowable in a GeoPackage implementation of the DGIWG profile if an extension does not conflict with a Mandatory extension. Only the extensions listed in Table-8 are enforced with compliance per conformance classes for extensions in ATS A.3.

A modification to this specification is necessary for an extension that adds to or supersedes the extensions in Table-8 when the extension is considered a Mandatory, Optional, or Not Allowed extension. Where two versions of the extension exist, a preference for a more recent version is given if it supersedes the previous extension.

6.4 File Names

When the DGIWG profile is implemented to define a minimum set of metadata, the users and clients can query the metadata in the GeoPackage for more information about the contents. The metadata required in sections 7.3, 8.4, and 9.1 describes the contents of the GeoPackage and its layers with more fidelity than contained in the file name. If a metadata query is not suitable for the user's search for GeoPackage files, the GeoPackage file name can provide useful elements about the contents of the GeoPackage.

The GeoPackage producer may follow the guidance in this section to name GeoPackage files. In this case, GeoPackage file names should include the following elements:

- GeoPackage Producer
- Data Product
- Geographic Coverage Area
- Zoom Levels
- Version
- GeoPackage Creation Date

Additional elements may be added to the file names for mission or agency-specific use. Elements should be ordered from general to specific, with "_" used to delimit elements and "-" used to delimit words within an element. The following general pattern should be used:

{Producer}_{Data Product}_{Geo Coverage Area}_{Zoom Levels}_{Version}_{Date}

The examples below provide further guidance on file names for DGIWG GeoPackages:

Table 9: DGIWG GeoPackage example

GeoPackage Example	**"AGC_BUCK_Ft-Bliss_14-20_v1-0_29AUG2016.gpkg"**	**"OGL_BOUND_UK_10K_v1-0_09APR2020.gpkg"**
GeoPackage Producer	*Army Geospatial Center (AGC)*	*Open Government Licence (OGL)*
Data Product(s)	*Buckeye*	*Boundary-Line*
Geographic Coverage Area	*Fort Bliss, Texas, USA*	*UK*
Zoom Levels	*14-20*	*-*
Scale Levels	*-*	*1:10,000*
Version	*1.0*	*1.0*
Creation Date	*29 August 2016*	*09 April 2020*

The differences between both GeoPackage examples are mainly because they are both from different countries. Also, some use cases require higher zoom levels to create a gpkg.

GeoPackage versions should be updated in a consistent manner. Minor version updates (“v1-1”) may be used to indicate that new features and/or tiles have been added to the existing raster tile pyramid or feature data set. Major version updates (“v2-0”) may be used to indicate that the tiles and/or features are substantially different than in the previous version.

7 Tiles and Features

7.1 Coordinate Reference Systems

This clause specifies allowable CRS and their WKT definitions that will be included in the DGIWG GeoPackages. In this document, CRS is the preferred and more accurate terminology. Spatial Reference Systems (SRS) is not used in this document except in pre-existing field names. These CRS are used in the gpkg_spatial_ref_sys table and referenced by the srs_id column values in gpkg_contents, gpkg_tile_matrix_set and gpkg_geometry_columns table.

The DGIWG GeoPackage profile uses the 2-dimensional (2D) tiles matrix sets (TMS) defined in Annex D of the "OGC Two Dimensional Tile Matrix Set" ([6] OGC 17-083r2) as required in section 8.2. The CRS defined and named in the tables below correspond to the eight tile matrix sets defined in Annex D of [6]. An additional projection for Lambert Conformal Conic (LCC) is listed for NATO member country interoperability.

The CRSs that are allowed for 2D DGIWG GeoPackage data are listed in Table-11 and Table-13. DGIWG GeoPackages use raster 3-dimensional (3D) matrix sets as described in Table-12 below. The term *Recommended Use* in the DGIWG profile of GeoPackage applies to GeoPackage data produced and applications consuming GeoPackage with the CRS. Geospatial clients are expected to support all the GeoPackage CRS for Relative Positioning and Navigation Recommended Use. Geospatial clients are not required to use the GeoPackage data in a CRS other than those required in this section, but are expected to still be operable or gracefully reject GeoPackage data in an unsupported CRS. The CRS listed in Table-10 states the most restrictive Recommended Use of the CRS for each the tile matrix sets defined by the 2D Tile Matrix Sets [6] (D.1 to D.8) and the LCC projection required by NATO AGeoP-21. A use of "country specific usage" only does not require a DGIWG implementation.

Table 10: Tile Matrix Set CRSs for DGIWG GeoPackage Profile

2D Tile Matrix OGC 17-083r2 section	DGIWG Recommended Use	Tile matrix set name	CRS - EPSG
D.1	Visualization and Situational Awareness	Web Mercator Quad TileMatrixSet	EPSG:3857
D.2	Relative positioning & Navigation	World CRS84 Quad TileMatrixSet	EPSG:4326 in lat, lon order Annex E [1]
D.3	Relative positioning & Navigation	World Mercator WGS84 Quad TileMatrixSet	EPSG:3395

2D Tile Matrix OGC 17-083r2 section	DGIWG Recommended Use	Tile matrix set name	CRS - EPSG
D.4	Relative positioning, country-specific usage	Universal Transverse Mercator WGS84 Quad family TileMatrixSet	EPSG:32601 - 32660, 32701 - 32760
D.5	Relative positioning & Navigation	Arctic Universal Polar Stereographic WGS 84 Quad TileMatrixSet	EPSG:5041
D.6	Relative positioning & Navigation	Antarctic Universal Polar Stereographic WGS84 Quad TileMatrixSet	EPSG:5042
D.7	Not required, country-specific usage	European ETRS89 LAEA Quad TileMatrixSet	EPSG:3035
D.8	Not required, country-specific usage	Canadian NAD83 LCC TileMatrixSet	EPSG:3978 (NAD83)
N/A	Relative positioning & Navigation	Lambert Conformal Conic - per product TileMatrixSet	projections using EPSG 9801 or 9802 coordinate operation

Note D.1 EPSG 3857, Web Mercator, is a common standard used for web mapping applications. It is used by virtually all major online map providers, including Google Maps, Bing Maps, OpenStreetMap, Mapquest, Esri, Mapbox, and others. **If using WMTS map data from a Volunteered Geographic Information (VGI) or commodity data source which is in the Web Mercator projection, it is highly recommended that your service warn users that this data is suitable for Visualization use cases only. For defence use cases and operations that require precise locations and precise navigation (land, air, and sea), one of the 5 CRS with permitted use for relative positioning and navigation, such as the World Mercator projection EPSG:3395, is mandatory.**

Table-11 lists the CRSs that are recommended for raster tile pyramid DGIWG GeoPackages viewed in 2D Map software applications, and Table-12 lists the CRSs that are recommended for raster tile pyramid DGIWG GeoPackages viewed in 3D Globe software applications. Table-13 lists the CRSs that are used for vector feature DGIWG GeoPackages, including both 2D and 3D vector features.

The following Requirement /req/crs/raster-allowed does not apply to "Tiled Gridded Coverage Data" as described in "OGC 17-066r2, OGC GeoPackage Extension for Tiled Gridded Coverage Data" [5]. This type of data has to be referenced in the "gpkg_contents" table with the value "2d-gridded-coverage" for the "data_type" column. If necessary, other CRS requirements can be

defined for this type of data in a specific DGIWG profile.

CRS parameter values adhere to be those stated in Table-14 through Table-25 of Section 7.2 (WKT). Parameter values for CRS defined by EPSG are those specified by the EPSG Geodetic Parameter Registry when this document was published.

Applications that can read standard GeoPackages can read the specified CRS definitions in the gpkg_spatial_ref_sys table.

Requirement 7	/req/crs/raster-allowed ***The CRSs listed in Table-11 and Table-12 SHALL be the only CRSs used by raster tile pyramid tables in a GeoPackage.***

Note: The integer codes assigned to DGIWG CRSs in this document meet two conditions to avoid confusion with CRS codes used for data imported from external sources and converted to a CRS defined by DGIWG. First, they are unique among all srs_id values referenced by the base GeoPackage specification and those defined in this document. Second, they do not duplicate the codes for any CRSs registered in https://epsg.org, although some of them duplicate codes for coordinate operations and other items in that registry, where codes are unique within a type. It is recommended that these conditions continue to be met if these codes are changed by the appropriate DGIWG authority.

Table 11: Raster Tile Pyramid Projected Coordinate Reference Systems recommended for use in 2D Map Applications

CRS Name	CRS AUTH ID	CRS Type	CRS Dimension	CRS Def
WGS 84 / World Mercator	EPSG 3395	PROJ	2	Table 16
WGS 84 / UPS North (E,N)	EPSG 5041	PROJ	2	Table 17
WGS 84 / UPS South (E,N)	EPSG 5042	PROJ	2	Table 18
WGS 84 / Web Pseudo-Mercator	EPSG 3857	PROJ	2	Table 19
WGS 84 / UTM zone 01-60N	EPSG 32601-32660	PROJ	2	Table 20
WGS 84 / UTM zone 01-60S	EPSG 32701-32760	PROJ	2	Table 20

CRS Name	CRS AUTH ID	CRS Type	CRS Dimension	CRS Def
WGS 84 / Lambert Conformal Conic using 1SP	per product	PROJ	2	Table 21
WGS 84 / Lambert Conformal Conic using 2SP	per product	PROJ	2	Table 22

Table 12: Raster Tile Pyramid Coordinate Reference Systems recommended for use in 3D Globe Applications

CRS Name	CRS AUTH ID	CRS Type	CRS Dimension	CRS Def
WGS 84 Geographic 2D	EPSG 4326	GEOD	2	Table 15
WGS 84 Geographic 3D	EPSG 4979	GEOD	3	Table 14
WGS 84 / World Mercator	EPSG 3395	PROJ	2	Table 16
WGS 84 / UPS North (E,N)	EPSG 5041	PROJ	2	Table 17
WGS 84 / UPS South (E,N)	EPSG 5042	PROJ	2	Table 18

Requirement 8	/req/crs/raster-tile-matrix-set ***WGS 84 Geographic 2D (EPSG::4326), World Mercator (EPSG::3395), UPS North/South (EPSG::5041/5042), and UTM (EPSG::362--, EPSG::327--) raster tile pyramid GeoPackages SHALL follow the technical requirements provided in OGC 17-083r2 (OGC Two Dimensional Tile Matrix Set Standard) for implementation of Tile Matrix Sets.***

Table 13: Vector feature Coordinate Reference Systems

CRS Name	CRS AUTH ID	CRS Type	CRS Dim	CRS Def
WGS 84 Geographic 2D	EPSG 4326	GEOD	2	Table 15
WGS 84 Geographic 3D	EPSG 4979	GEOD	3	Table 14
WGS84 4326 + EGM2008 height 3855	EPSG 9518	COMP	3	Table 24, Table 25
EGM2008 geoid height	EPSG 3855	VERT	1	Table 23

Requirement 9	/req/crs/2d-vector ***The 2D CRS in Table-13 SHALL be the only CRS used for 2D vector features in GeoPackage.***

Requirement 10	/req/crs/3d-vector ***The 3D CRS or compound CRS in Table-13 SHALL be the only CRS used for 3D vector features in GeoPackage.***

The CRS definitions in Table-14 through Table-25 in section 7.2 are used to specify the CRS for the raster tiles and vector feature user data tables data in a DGIWG GeoPackage.

Note: Annex C provides a link to the Coordinate Reference Systems (CRS) defined in this clause and the corresponding identifiers in the EPSG.

7.2 Well Known Text

This clause specifies allowable WKT definitions that are included in the DGIWG GeoPackages. CRS parameter values correlate to those in Table-13 through Table-24 below. Parameter values for CRS defined by EPSG are those specified by the EPSG Geodetic Parameter Registry when this document was published.

Requirement 11	/req/crs/wkt ***The CRS definitions in Table-14 through Table-23 in section 7.2 SHALL be used to specify the CRS used for tiles and vector features in a DGIWG compliant GeoPackage.***

WKT1 [8] specifies a WKT encoding for a 3D geodetic CRS, and a way to correctly specify the axis directions for polar stereographic projections, which are required for this profile. The WKT values in the gpkg_spatial_ref_sys columns are expressed in the definition column in the gpkg_spatial_ref_sys table, which is based on WKT in OGC 01-009. This DGIWG profile requires GeoPackage extension F.10 gpkg_crs_wkt to be used with WKT1 [8] expressed in column definition_12_063 for all supported CRS. Extension F.10 / Requirement 117 in GeoPackage 1.3.1 states that column definition_12_063 takes precedence if both definition values are defined.

If the optional AXIS terms are not present in the WKT, then the following default values are assumed [OGC 1-009, section 7.3.2].

- Geographic Coordinate Systems: AXIS[“Lon”,EAST],AXIS[“Lat”,NORTH]
- Projected Coordinate System: AXIS[“X”,EAST],AXIS[“Y”,NORTH]
- Geocentric Coordinate System: AXIS[“X”,OTHER],AXIS[“Y”,EAST],AXIS[“Z”,NORTH]

Editor note: the OGC GeoPackage extension *WKT for Coordinate Reference Systems Extension* (21-057, approved in 2022) allows WKT in the definition_063 column to conform to WKT1 [8] and WKT 2 (OGC 18-010r7). The GeoPackage profile only requires WKT1, which is compatible with WKT2 and fully defines all the CRS defined in this section without using the additional definition of WKT2.

Table 14: WGS 84 Geographic 3D CRS Definition Annex E [2]

gpkg_spatial_ref_sys Column Name : value
srs_name : http://www.opengis.net/def/crs/EPSG/0/4979
srs_id : 4979 Annex E [3]

gpkg_spatial_ref_sys Column Name : value
organization : EPSG
organization_coordsys_id : 4979
description : Used by the GPS satellite navigation system and for NATO military geodetic surveying.
definition :

```
GEODCRS["WGS 84",
    DATUM["World Geodetic System 1984",
        ELLIPSOID["WGS 84",6378137,298.257223563,
            LENGTHUNIT["metre",1.0]]],
    CS[ellipsoidal,3],
    AXIS["Geodetic latitude (Lat)",north,
        ANGLEUNIT["degree",0.0174532925199433]],
    AXIS["Geodetic longitude (Long)",east,
        ANGLEUNIT["degree",0.0174532925199433]],
    AXIS["Ellipsoidal height (h)",up,
        LENGTHUNIT["metre",1.0]],
    ID["EPSG",4979]]
```

OGC ISO 19125-1:2004 and OGC 01-009 specify a WKT encoding for the WGS 84 Geographic 2D CRS which ensures interoperability with existing GeoPackage implementations.

Table 15: WGS 84 Geographic 2D CRS Definition Annex E [4]

gpkg_spatial_ref_sys Column Name : value
srs_name : http://www.opengis.net/def/crs/EPSG/0/4326
srs_id : 4326
organization : EPSG
organization_coordsys_id : 4326
description : Horizontal component of 3D system. Used by the GPS satellite navigation system and for NATO military geodetic surveying.
definition :

```
GEOCCS["WGS 84",
    DATUM["WGS_1984",
        SPHEROID["WGS84",6378137,298.257223563]],
    PRIMEM["Greenwich",0],
    UNIT["degree",0.0174532925199433]]
```

Table 16: WGS 84 / World Mercator Projected CRS Definition

gpkg_spatial_ref_sys Column Name : value
srs_name : http://www.opengis.net/def/crs/EPSG/0/3395
srs_id : 3395
organization : EPSG
organization_coordsys_id : 3395
description : Mercator view of world excluding polar areas for very small scale mapping
definition :

```
PROJCRS["WGS 84 / World Mercator",
   BASEGEODCRS["WGS 84",
       DATUM["World Geodetic System 1984",
           ELLIPSOID["WGS 84",6378137,298.257223563]]],
   CONVERSION["Mercator",
       METHOD["Mercator (variant A)",
           ID["EPSG","9804"]],
       PARAMETER["Latitude of natural origin",0,
           ANGLEUNIT["degree",0.0174532925199433]],
       PARAMETER["Longitude of natural origin",0,
           ANGLEUNIT["degree",0.0174532925199433]],
       PARAMETER["Scale factor at natural origin",1,
           SCALEUNIT["unity",1.0]],
       PARAMETER["False easting",0,
           LENGTHUNIT["metre",1.0]],
       PARAMETER["False northing",0,
           LENGTHUNIT["metre",1.0]],
       ID["EPSG","19833"]],
   CS[Cartesian,2],
   AXIS["Easting (E)",east,
       ORDER[1]],
   AXIS["Northing (N)",north,
       ORDER[2]],
   LENGTHUNIT["metre",1.0],
   ID["EPSG","3395"]]
```

Table 17: WGS 84 / UPS North (E,N) Projected CRS Definition

gpkg_spatial_ref_sys Column Name : value
srs_name : http://www.opengis.net/def/crs/EPSG/0/5041
srs_id : 5041
organization : EPSG
organization_coordsys_id : 5041
description : Military mapping by NATO north of 60° N
definition :

```
PROJCRS["WGS 84 / UPS North (E,N)",
    BASEGEODCRS["WGS 84",
        DATUM["World Geodetic System 1984",
            ELLIPSOID["WGS 84",6378137,298.257223563,
                LENGTHUNIT["metre",1.0]]],
    CONVERSION["Universal Polar Stereographic North",
        METHOD["Polar Stereographic (variant A)",
            ID["EPSG","9810"]],
        PARAMETER["Latitude of natural origin",90,
            ANGLEUNIT["degree",0.0174532925199433]],
        PARAMETER["Longitude of natural origin",0,
            ANGLEUNIT["degree",0.0174532925199433]],
        PARAMETER["Scale factor at natural origin",0.994,
            SCALEUNIT["unity",1.0]],
        PARAMETER["False easting",2000000,
            LENGTHUNIT["metre",1.0]],
        PARAMETER["False northing",2000000,
            LENGTHUNIT["metre",1.0]],
        ID["EPSG","16061"]],
    CS[Cartesian,2],
    AXIS["Easting (E)",south,
        MERIDIAN[90,
            ANGLEUNIT["degree",0.0174532925199433]],
        ORDER[1]],
    AXIS["Northing (N)",south,
        MERIDIAN[180,
            ANGLEUNIT["degree",0.0174532925199433]],
        ORDER[2]],
    LENGTHUNIT["metre",1.0],
    ID["EPSG","5041"]]
```

Table 18: WGS 84 / UPS South (E,N) Projected CRS Definition

gpkg_spatial_ref_sys Column Name : value
srs_name : http://www.opengis.net/def/crs/EPSG/0/5042
srs_id : 5042
organization : EPSG
organization_coordsys_id : 5042
description : Military mapping by NATO south of 60° S
definition :

```
PROJCRS["WGS 84 / UPS South (E,N)",
    BASEGEODCRS["WGS 84",
        DATUM["World Geodetic System 1984",
            ELLIPSOID["WGS 84",6378137,298.257223563,
                LENGTHUNIT["metre",1.0]]]],
    CONVERSION["Universal Polar Stereographic North",
        METHOD["Polar Stereographic (variant A)",
            ID["EPSG","9810"]],
        PARAMETER["Latitude of natural origin",-90,
            ANGLEUNIT["degree",0.0174532925199433]],
        PARAMETER["Longitude of natural origin",0,
            ANGLEUNIT["degree",0.0174532925199433]],
        PARAMETER["Scale factor at natural origin",0.994,
            SCALEUNIT["unity",1.0]],
        PARAMETER["False easting",2000000,
            LENGTHUNIT["metre",1.0]],
        PARAMETER["False northing",2000000,
            LENGTHUNIT["metre",1.0]],
        ID["EPSG","16161"]],
    CS[Cartesian,2],
    AXIS["Easting (E)",north,
        MERIDIAN[90,
            ANGLEUNIT["degree",0.0174532925199433]],
        ORDER[1]],
    AXIS["Northing (N)",north,
        MERIDIAN[0,
            ANGLEUNIT["degree",0.0174532925199433]],
        ORDER[2]],
    LENGTHUNIT["metre",1.0],
    ID["EPSG","5042"]]
```

Table 19: Web Mercator Quad Tile Matrix Set

gpkg_spatial_ref_sys Column Name : value
srs_name : http://www.opengis.net/def/crs/EPSG/0/3857
srs_id : 3857
organization : EPSG
organization_coordsys_id : 3857
description : Uses spherical development of ellipsoidal coordinates. This should only be used for visualization purposes.
definition :

```
PROJCS["WGS 84 / Pseudo-Mercator",
    GEOGCS["WGS 84",
        DATUM["WGS_1984",
            SPHEROID["WGS 84",6378137,298.257223563,
                ID["EPSG","7030"]],
            ID["EPSG","6326"]],
        PRIMEM["Greenwich",0,
            ID["EPSG","8901"]],
        UNIT["degree",0.0174532925199433,
            ID["EPSG","9122"]],
        ID["EPSG","4326"]],
    PROJECTION["Mercator_1SP"],
    PARAMETER["central_meridian",0],
    PARAMETER["scale_factor",1],
    PARAMETER["false_easting",0],
    PARAMETER["false_northing",0],
    UNIT["metre",1,
        ID["EPSG","9001"]],
    AXIS["X",EAST],
    AXIS["Y",NORTH],
    ID["EPSG","3857"]]
```

Table 20: Universal Transverse Mercator WGS84 Quad Family TileMatrixSet

gpkg_spatial_ref_sys Column Name : value
srs_name : [http://www.opengis.net/def/crs/EPSG/0/32601 - http://www.opengis.net/def/crs/EPSG/0/32660]
srs_id : 32601 - 32660, 32701-32760
organization : EPSG
organization_coordsys_id : 32601 - 32660, 32701-32760
description : Each UTM Zone is a universal grid with an instance of the transverse mercator projection, onshore and offshore. Extent details - each UTM zone spans 6° of longitude between 174°E and 180°E, latitude in northern hemisphere between equator and 84°N, southern hemisphere between equator and 80°S.
definition :

```
PROJCS["WGS 84 / UTM zone <zone><hemisphere>",
    GEOGCS["WGS 84",
        DATUM["WGS_1984",
            SPHEROID["WGS84",6378137,298.257223563,
                ID["EPSG","7030"]],
            ID["EPSG","6326"]],
        PRIMEM["Greenwich",0,
            ID["EPSG","8901"]],
        UNIT["degree",0.0174532925199433,
            ID["EPSG","9122"]],
        ID["EPSG","4326"]],
    PROJECTION["Transverse_Mercator"],
    PARAMETER["latitude_of_origin",0],
    PARAMETER["central_meridian",<central_meridian>],
    PARAMETER["scale_factor",0.9996],
    PARAMETER["false_easting",500000],
    PARAMETER["false_northing",<false northing>],
    UNIT["metre",1,
        ID["EPSG","9001"]],
    AXIS["Easting",EAST],
    AXIS["Northing",NORTH],
    ID["EPSG","<epsg reference code>"]]

<zone> := >= 1 AND <= 60
<hemisphere> := N OR S
<central_meridian> := >= -177 AND <= 177
<false northing> := 0 for N, 10000000 for S
```

In Table-21 and Table-22, the values within <name> are variables to be replaced by the instantiation of a Lambert Conic Conformal (LCC) projection used in the GeoPackage. The allowable values for LCC projections are constrained in this profile as defined in section 7.4 Table-30.

Table 21: Lambert Conic Conformal using 1SP

gpkg_spatial_ref_sys Column Name : value
srs_name : <registered name> Lambert Conformal Conic using 1SP
srs_id : <registered LCC 1SP SRS>
organization : EPSG
organization_coordsys_id : <registered LCC 1SP CRS>
description :For a one standard parallel Lambert the natural origin of the projected coordinate system is the intersection of the standard parallel with the longitude of origin (central meridian).
definition :

```
Lambert_Conic_Conformal_using_1SP

PROJCS["<name>",
    GEODCRS | GEOGCS["<CRS Reference>",
        DATUM["<datum reference>",
            SPHEROID["<spheroid>",<semi-major axis>,<inverse flattening>]],
        PRIMEM["<prime meridian name>",<irm_longitude>],
        UNIT["degree",0.0174532925199433]],
    PROJECTION["Lambert_Conformal_Conic_1SP"],
    PARAMETER["latitude_of_origin",<latitude_of_origin>],
    PARAMETER["central_meridian",<central_meridian>],
    PARAMETER["scale_factor",<scale_factor>],
    PARAMETER["false_easting",<false_easting>],
    PARAMETER["false_northing",<false_northing>],
    UNIT["Meter",1],
    AXIS["X",EAST],
    AXIS["Y",NORTH],
    AUTHORITY["EPSG","<srs_id>"]]
```

Example Value :

```
PROJCS["Unnamed Lambert_Conformal_Conic using 1SP",
    GEOGCS["NAD83",
        DATUM["North_American_Datum_1983",
            SPHEROID["GRS 1980",6378137,298.257222101],
            AUTHORITY["EPSG","6269"]],
        PRIMEM["Greenwich",0],
        UNIT["degree",0.0174532925199433]],
    PROJECTION["Lambert_Conformal_Conic_1SP"],
    PARAMETER["latitude_of_origin",49],
    PARAMETER["central_meridian",-95],
    PARAMETER["scale_factor",1],
    PARAMETER["false_easting",0],
    PARAMETER["false_northing",0],
    UNIT["Meter",1],
    AXIS["X",EAST],
    AXIS["Y",NORTH],
    AUTHORITY["EPSG","0000"]]
```

Table 22: Lambert Conic Conformal using 2SP

gpkg_spatial_ref_sys Column Name : value
srs_name : <registered name> Lambert Conformal Conic using 2SP
srs_id : <registered LCC 2SP SRS>
organization : EPSG
organization_coordsys_id : <registered LCC 2SP SRS>
description : Two standard parallels will usually be made according to the latitudinal extent of the area which it is wished to map, the parallels usually being chosen so that they each lie a proportion inboard of the north and south margins of the mapped area.
definition :

```
Lambert_Conic_Conformal_using_2SP

PROJCS["<name>",
    GEODCRS | GEOGCS["<CRS Reference>",
        DATUM["<datum reference>",
            SPHEROID["<spheroid>",<semi-major axis>,<inverse flattening>]],
        PRIMEM["<prime meridian name>",<irm_longitude>],
        UNIT["degree",0.01745329251994328]],
    PROJECTION["Lambert_Conformal_Conic_2SP"],
    PARAMETER["standard_parallel_1",<standard_parallel_1>],
    PARAMETER["standard_parallel_2",<standard_parallel_2>],
    PARAMETER["latitude_of_origin",<latitude_of_origin>],
    PARAMETER["central_meridian",<central_meridian>],
    PARAMETER["false_easting",<false_easting>],
    PARAMETER["false_northing",<false_northing>],
    AXIS[X,EAST],
    AXIS[Y,NORTH],
    AUTHORITY["EPSG","<srs_id>"]]
```

Example Value :

```
PROJCS["NAD83 / Canada Atlas Lambert",
    GEOGCS["NAD83",
        DATUM["North_American_Datum_1983",
            SPHEROID["GRS 1980",6378137,298.257222101,
                AUTHORITY["EPSG","7019"]],
            AUTHORITY["EPSG","6269"]],
        PRIMEM["Greenwich",0,
            AUTHORITY["EPSG","8901"]],
        UNIT["degree",0.01745329251994328,
            AUTHORITY["EPSG","9122"]],
        AUTHORITY["EPSG","4269"]],
    UNIT["metre",1,
        AUTHORITY["EPSG","9001"]],
    PROJECTION["Lambert_Conformal_Conic_2SP"],
    PARAMETER["standard_parallel_1",49],
    PARAMETER["standard_parallel_2",77],
    PARAMETER["latitude_of_origin",49],
    PARAMETER["central_meridian",-95],
    PARAMETER["false_easting",0],
    PARAMETER["false_northing",0],
    AXIS["Easting",EAST],
    AXIS["Northing",NORTH],
    AUTHORITY["EPSG","3978"]]
```

Compound CRS

Requirement 12	/req/crs/compound ***If a GeoPackage contains feature data where the gpkg_geometry_column does not allow Z geometry values, a Compound CRS SHALL not be used as a CRS definition.***

Three dimensional CRS can be defined using a Compound CRS following Table-23, Table-24, and Table-25. The Compound CRS elements are combined in this example Compound CRS WKT definition.

```
COMPOUNDCRS["WGS84 Height EGM08",
    GEODCRS["WGS 84",
        DATUM["World Geodetic System 1984",
            ELLIPSOID["WGS 84",6378137,298.257223563,
                LENGTHUNIT["metre",1.0]]],
        CS[ellipsoidal,2],
        AXIS["Geodetic latitude (Lat)",north],
        AXIS["Geodetic longitude (Long)",east],
        ANGLEUNIT["degree",0.0174532925199433],
        ID["EPSG",4326]],
    VERTCRS["EGM2008 geoid height",
        VDATUM["EGM2008 geoid",
            ANCHOR["WGS 84 ellipsoid"]],
        CS[vertical,1],
        AXIS["Gravity-related height (H)",up],
        LENGTHUNIT["metre",1.0],
        ID["EPSG",3855]],
    ID["EPSG",9518]]
```

Table 23: EGM2008 geoid height vertical CRS Definition

gpkg_spatial_ref_sys Column Name : value
srs_name : EGM2008 height Vertical
srs_id : 3855
organization : EPSG
organization_coordsys_id : 3855
description : Good approximation of Orthometric height above the EGM2008 model of the geoid. Replaces EGM96 geoid (CRS code 5773).
definition :

```
VERTCRS["EGM2008 geoid height",
    VDATUM["EGM2008 geoid",
        ANCHOR["WGS 84 ellipsoid"]],
    CS[vertical,1],
    AXIS["Gravity-related height (H)",up],
    LENGTHUNIT["metre",1.0],
    ID["EPSG",3855]]
```

Table 24: Compound CRS Definition Template

gpkg_spatial_ref_sys Column Name : value
srs_name : <Compound CRS Name>
srs_id : <Comp CRS Code>
organization : EPSG
organization_coordsys_id : <Comp CRS Code>
description : Geodetic position based on the World Geodetic System 1984 (WGS 84), extended by height position based on the Earth Gravity Model 2008 (EGM08).
definition :

```
COMPOUNDCRS["Compound",
    ID["EPSG","Comp-CRS-Code"]]
```

Requirement 13	/req/crs/compound-wkt ***Template <parameters> <Comp CRS Code> and <Compound CRS Name> in Table-24 above SHALL be replaced with parameter values from Table-25 below. Template <parameters> <Head CRS> and <Tail CRS> in Table-2\4 above SHALL be replaced with definitions from the definition column values in the tables referenced from Table-25. These replacements SHALL be used to define compound CRS definitions.***

The compound CRS in Table-25 uses the WGS84 for X,Y coordinates and the Vertical CRS EGM2008 (3855 in the EPSG definition) for the Z coordinate.

Table 25: Compound CRS Template Parameter Values

<Comp CRS Code>	**<Compound CRS Name>**	**<Head CRS> Code**	**<Head CRS> Table**	**<Tail CRS> Code**	**<Tail CRS> Table**
EPSG 9518	WGS 84 + EGM2008 height Compound	4326	Table 14	3855	Table 22

7.3 Metadata

This clause describes the storage of metadata using the metadata extension F.8 to embed XML in GeoPackages. The DGIWG GeoPackage profile specifies the use of particular metadata values in certain conditions per the DGIWG Metadata Foundation (DMF) and associated metadata files. Optionally, metadata from a national profile (e.g. U.S. NSG Metadata Foundation (NMF)) can be included in a GeoPackage in addition to DMF.

The structure and allowed content values of DGIWG metadata for a GeoPackage are specified by the DMF. Examples of the creation use, and exchange of metadata in GeoPackage are described in these use cases: D-2 Disadvantaged, mobile, and autonomous users, D-3 Data Exchange between processing sites and D-6 Workflow for generating a GeoPackage.

A DGIWG GeoPackage is required to contain a DMF metadata instance for the *Entire GeoPackage* as defined in the tables described in this section, and it may optionally contain metadata instances of additional national metadata profiles.

The metadata in a GeoPackage is defined in two related tables, gpkg_metadata and gpkg_metadata_reference, which define metadata for the entire GeoPackage, a series of GeoPackage data, and optionally for subsets of the GeoPackage contents, referred to in this specification as a *Partial GeoPackage*. The requirements and related tables that follow in this section define the DGIWG implementation of metadata using the structure defined in the OGC GeoPackage standard.

Requirement 14	/req/metadata/dmf ***The metadata for the entire GeoPackage and, if present, metadata for a part of the GeoPackage vector layers or tile matrices SHALL include one or more complete metadata instance of DGIWG Metadata Foundation (DMF) 2.0 or later version.***

Annex B provides an informative metadata reference with mapping of DMF metadata elements to NMF core metadata, and examples of metadata content for each format.

Requirement 15	/req/metadata/gpkg ***A GeoPackage SHALL contain one or more complete metadata XML instance document that describes the entire GeoPackage in a gpkg_metadata table row with the contents shown in Table-26_below.***

Table 26: gpkg_metadata Table Contents - Required for Entire GeoPackage

Column Name	Column Description	Column Value
id	Metadata primary key	unique integer value
md_scope	Case sensitive name of the data scope to which this metadata applies	'series' or 'dataset'
md_standard_uri	URI reference to the metadata structure definition authority	REQUIRED URI location of the DGIWG standard for use in Table-27 through Table-32
mime_type	MIME encoding of metadata	text/xml
metadata	metadata	REQUIRED DMF metadata instance document

If national metadata is contained for the entire GeoPackage file or a series of GeoPackage files, the national metadata will be included according to the contents of Table-27. The national metadata is optional; but if populated, the contents are not NULL.

Table 27: gpkg_metadata Table Contents - Optional Metadata for Entire GeoPackage

Column Name	Column Description	Column Value
id	Metadata primary key	unique integer value
md_scope	Case sensitive name of the data scope to which this metadata applies	'series' or 'dataset'
md_standard_uri	URI reference to the metadata structure definition authority	URI location of the national metadata profile (ex. US NMF/NMIS)

Column Name	Column Description	Column Value
mime_type	MIME encoding of metadata	text/xml

Requirement 16	/req/metadata/row ***The gpkg_metadata table row with the values shown in Table-26 SHALL be associated with the complete GeoPackage by a gpkg_metadata_reference table row with the contents shown in Table-27.***

Table 28: gpkg_metadata_reference Table Contents - Entire GeoPackage

Column Name	Column Description	Column Value
reference_scope	Lowercase metadata reference scope	'geopackage'
table_name	NULL for reference_scope of 'geopackage'.	NULL
column_name	Name of the column to which this metadata reference applies; NULL for reference_scope of 'geopackage'	NULL
row_id_value	NULL for reference_scope of 'geopackage'	NULL
timestamp	timestamp value in ISO 8601format as defined by the strftime function '%Y-%m-%dT%H:%M:%fZ' format string applied to the current time	strftime('%Y-%m-%dT%H:%M:%fZ','now')
md_file_id	gpkg_metadata table id column value for the metadata to which this gpkg_metadata_reference applies	unique integer value, id field value for the gpkg_metadata contents in Table-26 or Table-27
md_parent_id	NULL if md_file_id forms the root of a metadata hierarchy	file id field value for the previous gpkg_metadata_reference contents, or NULL

A GeoPackage MAY contain additional metadata XML instance documents or fragments for a smaller subset of the GeoPackage that describe particular feature layers, TileMatrixSet layers, or other entities contained within the GeoPackage. For implementation of *Partial GeoPackage* metadata, the gpkg_metadata_reference table can identify other user-defined tables containing information about a subset of the GeoPackage contents for featureType, feature, attributeType, attribute, model (tileSet), and tile. More description of tile and feature metadata is written in sections 8.4, Tile Metadata, and 9.1, Feature Metadata.

An example of the tables used to define metadata for vector feature types in the GeoPackage is illustrated in three figures using the md_scope value *featureType* defined in Table-31. The GeoPackage geometry and attributes for each feature are contained in the user-defined tables roads and bridges. Users of the profile can store *featureType* metadata using the nominal definition of metadata tables depicted in Figure-1. The gpkg_metadata_reference identifies the rows in gpkg_metadata for the feature types in the geometry tables, roads_geom and bridges_geom. Alternatively, a user-defined table of feature types could be added as shown in Figure-2. In the second example, the GeoPackage populates the same rows of the gpkg_metadata table for two feature types. However, the instance in Figure-3 extends the nominal use of gpkg_metadata_reference to populate table_name and column_name columns for the user-defined table Feature_types, which contains feature type names. Beyond these examples, additional metadata for the roads and bridges tables could be populated in gpkg_metadata and gpkg_metadata_reference with a md_scope value of *feature*, *attribute_type*, or *attribute* (not depicted in these examples).

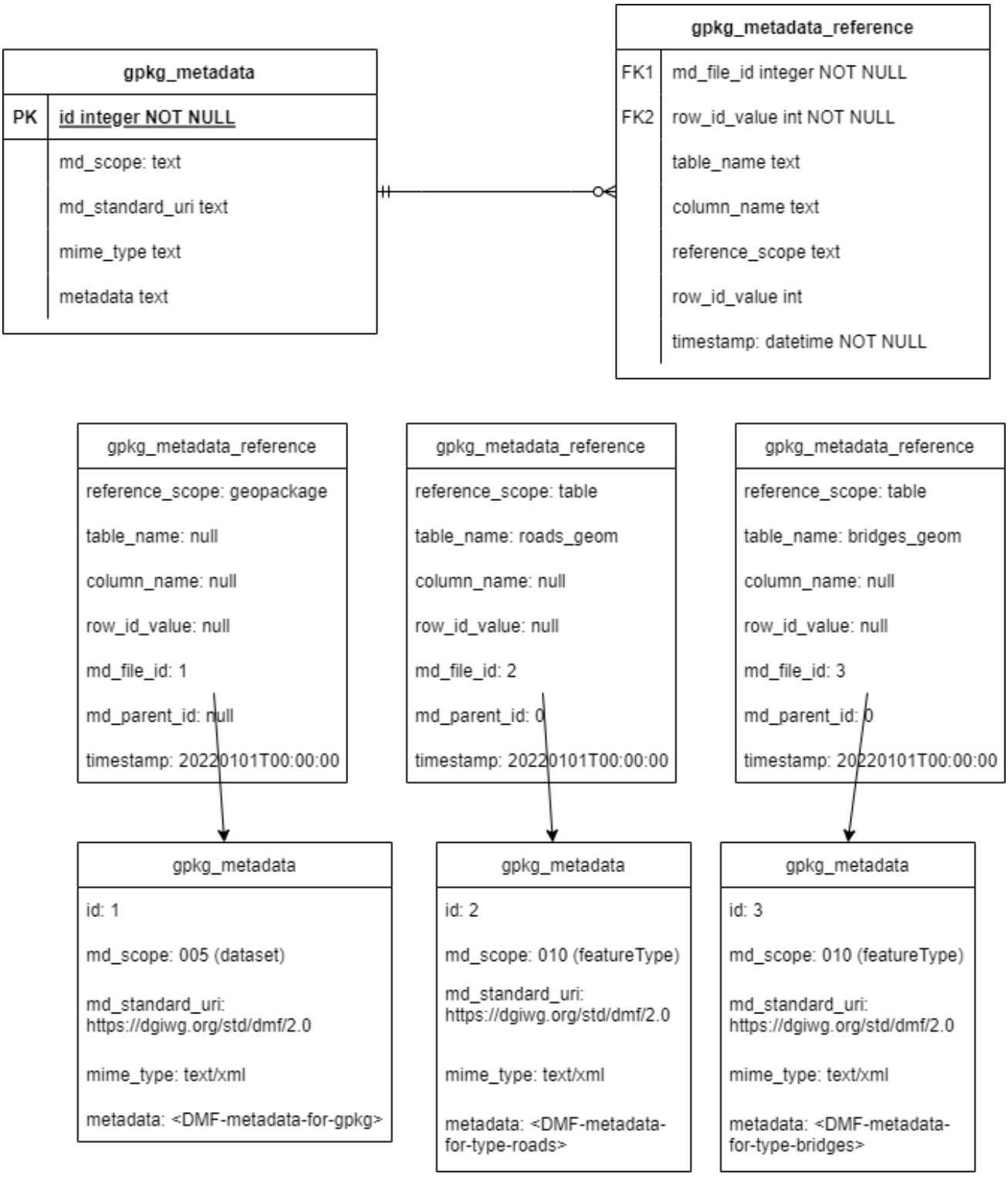

Figure 1: GeoPackage Feature Type Metadata Nominal Example

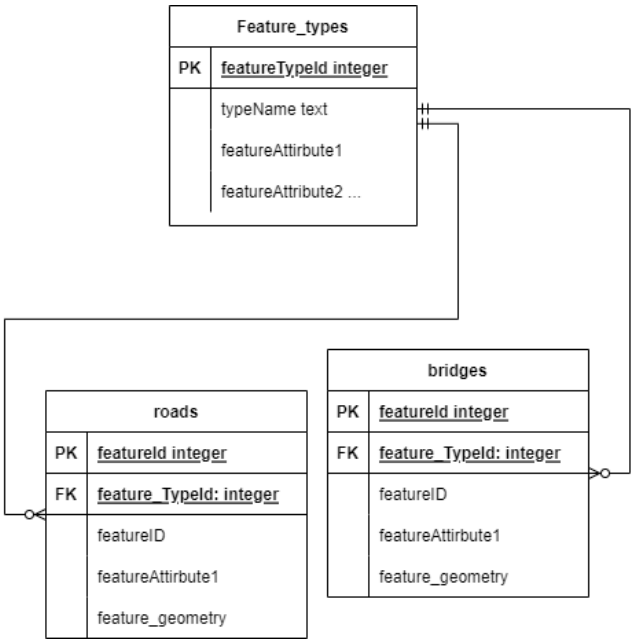

Figure 2: GeoPackage Feature Type Metadata Extended Example User Tables

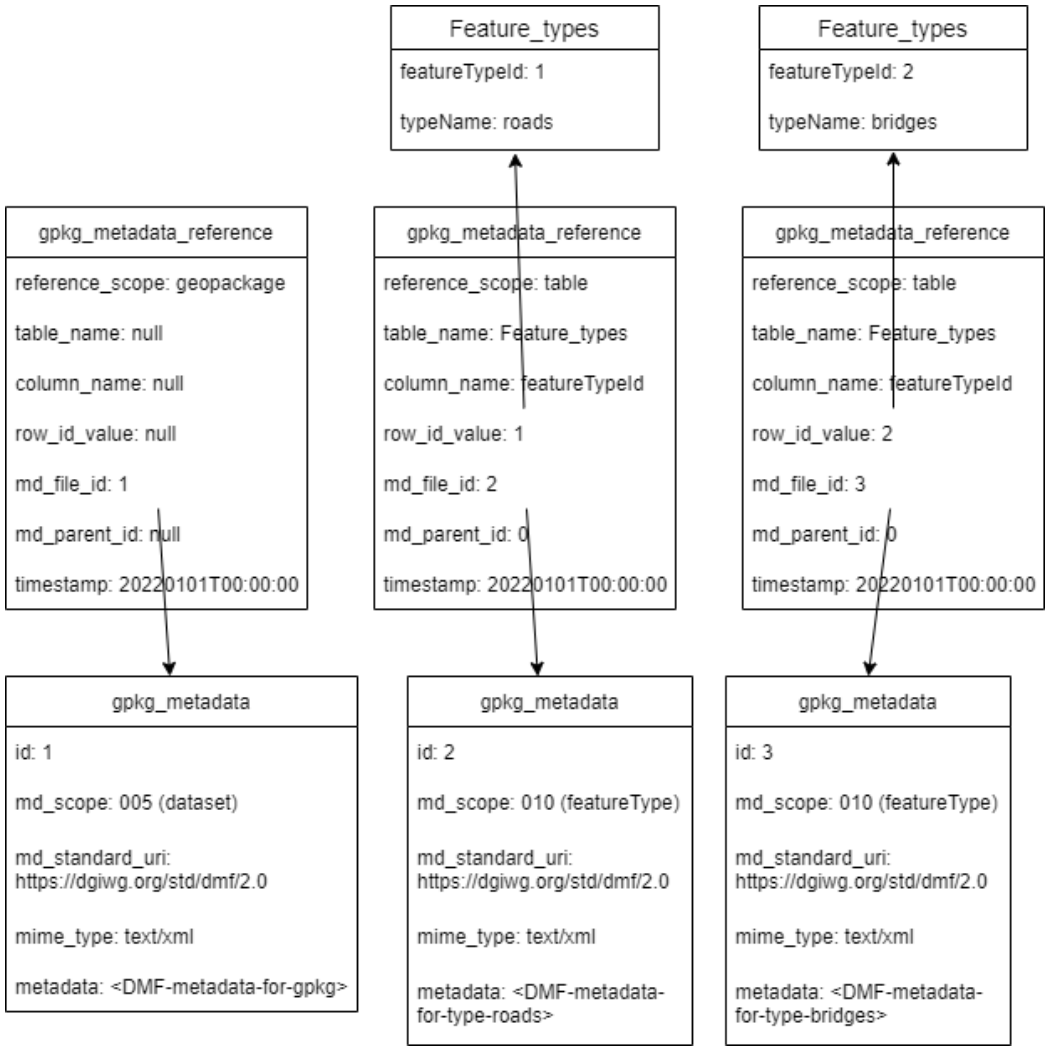

Figure 3: GeoPackage Feature Type Metadata Extended Example Instance

As illustrated in these figures, gpkg_metadata and gpkg_metadata_reference can optionally be utilized to contain the metadata for any *Partial GeoPackage* content. The metadata contained for reference_scope values of table, row, column, or row/col in Table-31 is specified for a GeoPackage in the gpkg_metadata contents in Table-29 and the corresponding gpkg_metadata_reference in Table-30.

Table 29: gpkg_metadata Table Contents - Partial GeoPackage

Column Name	Column Description	Column Value
id	Metadata primary key	unique integer value
md_scope	Case sensitive name of the data scope to which this metadata applies	See Table-31
md_standard_uri	URI reference to the metadata structure definition authority	REQUIRED URI location of the applicable DMF version OPTIONAL URI location of national metadata profile (ex. US NMIS)
mime_type	MIME encoding of metadata	text/xml
metadata	metadata	REQUIRED DMF metadata instance document OPTIONAL National metadata profile instance document

Requirement 17	/req/metadata/user ***If a GeoPackage contains metadata for vector layers or tile matrices, any gpkg_metadata table row with values AND applies to multiple GeoPackage table, row and/or column content items shown in Table-29 SHALL be linked to the specific row and/or column in that table by the md_file_id in gpkg_metadata_reference AND those content items by one or more gpkg_metadata_reference table rows with the content specified in Table-30.***

The connection between gpkg_metadata and gpkg_metadata_reference tables for GeoPackage user metadata in Requirement /req/metadata/user is the same type of connection for the whole GeoPackage in Requirement /req/metadata/row. This relationship is verified in ATS-4.3 and ATS-4.4.

Table 30: gpkg_metadata_reference Table Contents - Product Partial GeoPackage

Column Name	Column Description	Column Value
reference_scope	Lowercase metadata reference scope; one of ‘table’,’column’, ‘row’, ‘row/col’	See Table-31 below
table_name	Name of the table to which this metadata reference applies, not applicable unless optionally used for reference_scope of ‘table', ‘row’, 'column' or 'row/col' to describe a featureType, feature, tileSet, tile, attributeType, or attribute; else NULL.	As described, set to NULL if not applicable

Column Name	Column Description	Column Value
column_name	Name of the column to which this metadata reference applies; not applicable unless optionally used for reference_scope of ‘table’, 'row/col' or ‘row’, or the name of a column in the table_name table for reference_scope of ‘column’ or ‘row/col’ to describe a feature, tile, attributeType, or attribute; or optionally a column name in the table_name table for reference_scope of ‘table’ and gpkg_metadata.md_scope value of 'featureType', 'model' (tileSet), or 'attributeType'	As described, set to NULL if not applicable
row_id_value	NULL for reference_scope of ‘table’ or ‘column’ with NULL "table_name", or the row id of a row record in the table_name table for reference_scope of ‘table’, ‘column’, 'row' or ‘row/col’	As described, set to NULL if not applicable
timestamp	timestamp value in ISO 8601format as defined by the strftime function ‘%Y-%m-%dT%H:%M:%fZ’ format string applied to the current time	strftime(‘%Y-%m-%dT%H:%M:%fZ’,’now’)
md_file_id	gpkg_metadata table id column value for the metadata to which this partial gpkg_metadata_reference applies	unique integer value, id field value for the partial gpkg_metadata contents in Table-29

Column Name	Column Description	Column Value
md_parent_id	gpkg_metadata table id column value for the hierarchical parent gpkg_metadata for the gpkg_metadata to which this gpkg_metadata_reference applies, or NULL if md_file_id forms the root of a metadata hierarchy	file id field value for the previous partial gpkg_metadata_reference contents, or NULL

The md_scope and corresponding reference scope values for the DGIWG implementation of metadata are defined in Table-31. The scope code values for md_scope come from the GeoPackage specification [4], Table 21, Metadata Scopes. The enumeration for a *tileSet* is added in this DGIWG profile using the md_scope value for *model* because the tileSet code is not defined in the Metadata Scopes of the GeoPackage standard.

Table 31: GeoPackage and metadata scopes

gpkg_metadata. md_scope (scope code)	gpkg_metadata_reference. reference_scope
series (006)	table
dataset (005)	geopackage
featureType (010)	table
feature (009)	row
model (015) for a tileSet	table
tile (016)	row/col
attributeType (002)	column
attribute (001)	row/col

A GeoPackage may constitute a single product or a collection of products in one GeoPackage. The metadata content is capable of describing products within a GeoPackage. A hierarchy of product metadata is defined by use of the md_parent_id in the GeoPackage metadata reference table (gpkg_metadata_reference). The following Recommendation and two requirements (/req/metadata/product, /req/metadata/product-partial) address use of metadata for one or more products in a GeoPackage.

Recommendation 1	/recco/metadata-product ***If there is different kind of data (e.g. raster tiles and vector features, or aggregation of data from various origins) in the Geopackage, there should be a dataset metadata for each kind of data using the scope "table", in addition to the metadata for the whole Geopackage.***

Requirement 18	/req/metadata/product ***If an entire GeoPackage constitutes a data product, then the component elements above that describe it SHALL be in the metadata XML that applies to the entire GeoPackage as shown in Table-26.***

Requirement 19	/req/metadata/product-partial ***If particular tables in a GeoPackage constitute separate data products, those parts of Geopackage SHALL be described by a metadata element as defined in Table-29, and the component elements that describe those data products SHALL reference the appropriate subpart(s) of Geopackage as shown in Table-30.***

7.4 Data Validity Constraints

This clause specifies constraints on allowable data values in GeoPackage SQL tables to enable assessment and enforcement of data validity. Its requirements are conditional based on whether a GeoPackage contains features or tiles. It applies to tables specified in the table name column of Table-32 below.

GeoPackage Infrastructure and Applications MAY

- Maintain data validity after every SQL command that changes GeoPackage data when this is a critical requirement (e.g. for data extent or metadata). Doing so (e.g. with SQL triggers) can cause significant performance degradation.
- Maintain data validity after a sequence of SQL commands, or after some application-specific unit of work, or upon application startup and/or termination, when this is not a critical requirement. Doing so (e.g. with a background process or a “batch” job upon application termination) can provide significant performance enhancement.

Requirement 20	/req/validity/data-validity ***Data validity SHALL be assessed against data value constraints specified in Table-32 below using a test suite. Data validity MAY be enforced by SQL triggers.***

Table 32: Data Validity Constraints

ID#	Table Name	Column Name	Value Constraints
1	“gpkg_spatial_ref_sys”	“organization”	“EPSG”
2	“gpkg_spatial_ref_sys”	“description”	NOT NULL, not an empty string, not all whitespace, not “unknown” (any case), not “tbd” (any case). For CRS specified in section 7.2 above, “description” column value from Table-14 through Table-24

ID#	Table Name	Column Name	Value Constraints
3	“gpkg_spatial_ref_sys”	“definition”, "definition_12_063"	If PROJECTION is Lambert_Conformal_Conic_1SP, then DATUM = WGS84, or European_Terrestrial_Reference_System_1989, or North_American_Datum_1983. SPHEROID = WGS84, GRS 1980 PRIMEM = Greenwich, <irm_longitude> value between 0.0 and 359.0. PARAMETER – values according to a valid Lambert Conic Conformal projection for 1 standard parallel in Table-21 in section 7.2. PROJECTION AUTHORITY = Valid EPSG code for this LCC 1SP projection.
4	“gpkg_spatial_ref_sys”	“definition”, "definition_12_063"	If PROJECTION is Lambert_Conformal_Conic_2SP, then DATUM = WGS84, or European_Terrestrial_Reference_System_1989, or North_American_Datum_1983. SPHEROID = WGS84, GRS 1980 PRIMEM = Greenwich, <irm_longitude> value between 0.0 and 359.0. PARAMETER – values according to a valid Lambert Conic Conformal projection for 2 standard parallels in Table-22 in section 7.2. PROJECTION AUTHORITY = Valid EPSG code for this LCC 2SP projection.
5	“gpkg_spatial_ref_sys”	“definition_12_063”	Compatible with WKT1
6	“gpkg_contents”	“data_type”	“features” or “tiles” or an implementer-defined value for other data tables in an Extended GeoPackage.

ID#	Table Name	Column Name	Value Constraints
7	“gpkg_contents”	“min_x”	NULL if no information available, Otherwise: If gpkg_contents.data_type = “features”, value SHALL be >= the minimum ST_MinX({geom_col}) value from gpkg_contents.table_name. If gpkg_contents data_type = “tiles”, value SHALL be >= gpkg_tile_matrix_set.min_x column value for gpkg_contents.table_name.
8	“gpkg_contents”	“min_y”	NULL if no information available. Otherwise: If gpkg_contents.data_type = “features”, value SHALL be >= the minimum ST_MinY({geom_col}) value from gpkg_contents.table_name. If gpkg_contents data_type = “tiles”, value SHALL be >= gpkg_tile_matrix_set.min_y column value for gpkg_contents.table_name.
9	“gpkg_contents”	“max_x”	NULL if no information available. Otherwise: If gpkg_contents.data_type = “features”, value SHALL be <= the maximum ST_MaxX({geom_col}) value from gpkg_contents.table_name. If gpkg_contents data_type = “tiles”, value SHALL be <= gpkg_tile_matrix_set.max_x column value for gpkg_contents.table_name.
10	“gpkg_contents”	“max_y”	NULL if no information available. Otherwise: If gpkg_contents.data_type = “features”, value SHALL be <= the maximum ST_MaxY({geom_col}) value from gpkg_contents.table_name. If gpkg_contents data_type = “tiles”, value SHALL be <= gpkg_tile_matrix_set.max_y column value for gpkg_contents.table_name.

ID#	Table Name	Column Name	Value Constraints
11	“gpkg_geometry_columns”	“z”	not equal to 2: z values optional is prohibited
12	“gpkg_geometry_columns”	“z”	0: z values prohibited is required for all 2-D CRS, i.e. where definition column of gpkg_spatial_ref_sys with same srs_id value contains WKT definition starting with “GEODCRS” or “PROJCRS” per WKT1
13	“gpkg_geometry_columns”	“z”	1: z values mandatory is required for all 3-D CRS, i.e. where definition column of gpkg_spatial_ref_sys with same srs_id value contains WKT definition starting with “GEODCRS” or “COMPOUNDCRS” with either “GEODCRS” or “PROJCRS” and “VERTCRS” definitions per WKT1
14	Every gpkg_geomtry_columns table_name column value vector feature user data table name feat_table	Corresponding gpkg_geometry_columns column_name column value geom_col name	If corresponding gpkg_geometry_columns.z = 0, **SELECT** COUNT () ***FROM** feat_table **WHERE** ST_Is3D(geom_col) SHALL return 0. If z = 1, **SELECT** COUNT () ***FROM** feat_table **WHERE NOT** ST_Is3D(geom_col) SHALL return 0.
15	“gpkg_data_columns”	“constraint_name”	Column value constraint name may be mixed case (not all lowercase as in GeoPackage Annex F.9).
16	“gpkg_tile_matrix”	“zoom_level”	0 <= zoom_level <= max_level.
17	“gpkg_tile_matrix”	“tile_width”	256
18	“gpkg_tile_matrix”	“tile_height”	256
19	“gpkg_tile_matrix”	“pixel_x_size”	SHALL vary by a factor of 2 between all adjacent zoom levels for the same table_name.
20	“gpkg_tile_matrix”	“pixel_y_size”	SHALL vary by a factor of 2 between all adjacent zoom levels for the same table_name.
21	Every gpkg_contents table_name column value where data_type = “tiles”	“zoom_level”	0 < = zoom_level <= max_level.
22	“gpkg_metadata”	“id”	Unique value SHALL be used only for DGIWG DMF or other national (e.g. NSG NMF) Metadata versions for entire GeoPackage.

ID#	Table Name	Column Name	Value Constraints
23	“gpkg_metadata”	“md_scope”	equal to scope code for “series” or “dataset” for id = primary key of root of metadata hierarchy; else equal to scope code for "featureType", "feature", "model", "tile", "attributeType", or "attribute".
24	“gpkg_metadata”	“md_standard_uri”	valid URI for DGIWG DMF equal to "https://dgiwg.org/std/dmf/2.0", or higher DMF version, or an optional national (e.g. NSG NMF) Metadata uri for id = primary key of root of metadata hierarchy.
25	“gpkg_metadata”	“mime_type”	“text/xml”
26	“gpkg_metadata”	“metadata”	DGIWG DMF or national metadata (e.g. NSG NMF/NMIS) metadata instance document.
27	“gpkg_metadata_reference”	“reference_scope”	“geopackage” for md_file_id = primary key of root of metadata hierarchy; else equal "table", "row", "row/col", or "column".
28	“gpkg_metadata_reference”	“table_name”	NULL for md_file_id = primary key of root of metadata hierarchy; NOT NULL if reference_scope = "table", "row", "column", or "row/col"; else, NULL.
29	“gpkg_metadata_reference”	“column_name”	NULL for md_file_id = primary key of root of metadata hierarchy; NOT NULL for the column_name in the "table_name" used in gpkg_metadata_reference if reference_scope = "column" or "row/col"; else, NULL.
30	“gpkg_metadata_reference”	“row_id_value”	NOT NULL for the row_id in the "table_name" used in gpkg_metadata_reference for reference_scope = "table", "column", "row" or "row/col"; else, NULL.
31	“gpkg_metadata_reference”	“timestamp”	timestamp value in ISO 8601 format.
32	“gpkg_metadata_reference”	“md_file_id”	unique integer value required equal to the id field value for the gpkg_metadata to which it applies.
33	“gpkg_metadata_reference”	“md_parent_id”	NULL for md_file_id = primary key of root of metadata hierarchy; else "0" if not used in metadata hierarchy; else gpkg_metadata id value for parent to which this gpkg_metadata_reference applies in metadata hierarchy.

8 Tiles

8.1 Tile Size

This clause mandates 256x256 tiles in any tile pyramid user data tables defined in accordance with OGC GeoPackage Clause 2.2.8 that contain DGIWG data.

As noted in [4] GeoPackage 1.3.1 footnote [K23], when tiles on the edge of the bounding box at a particular zoom level are within but not equal to the bounding box, then the non-image area of matrix edge tiles must be padded with no-data values, preferably transparent ones.

Requirement 21	/req/tile/size-matrix ***The gpkg_tile_matrix table SHALL contain tile_width and tile_height column values of 256 for every table_name tile pyramid data table.***

Requirement 22	/req/tile/size-data ***Every tile_data tile in every table_name tile pyramid data table shall have a width and height of 256 pixels.***

8.2 Zoom Levels and Tile Matrix Sets

This clause specifies that pixel sizes vary by a factor of 2 between all adjacent zoom levels, adopting the commonly used "zoom times two" convention, and precluding the use of "zoom other intervals" conventions. It applies to any tile pyramid user data tables defined in accordance with Clause 2.2.8 [4] that contain DGIWG data.

Requirement 23	/req/zoom/factor ***The gpkg_tile_matrix table SHALL contain pixel_x_size and pixel_y_size column values that differ by a factor of 2 between all adjacent zoom levels for each tile pyramid data table per OGC GeoPackage Clause 2.2.3. It SHALL NOT contain pixel sizes that vary by irregular intervals or by regular intervals other than a factor of 2 between adjacent zoom levels per OGC GeoPackage Clause 2.2.3.***

Requirement /req/crs/raster-tile-matrix-set restricts the Tile Matrix Sets (formerly called Well-Known Scale Sets (WKSS)) used in GeoPackage raster tiles as defined in Annex D of [6] OGC 17-083r2 for the Tile Matrix Sets referenced in this specification. An exception to the <req-zoom-matrix-sets-multiple, /req/zoom/matrix-sets-multiple>> requirement is allowed for tile matrix sets that represent a single scale product, such as raster charts using the Lambert Conformal Conic projection, expressed in requirement /req/zoom/matrix-sets-one.

For requirement /req/zoom/matrix-sets-multiple, because requirement /req/zoom/factor requires all zoom levels to be adjacent, a subset of zoom levels from the OGC 2D TMS [6] must all be adjacent (i.e. consecutive). For example, a single tile matrix set with a subset of zoom levels for EPSG 3395 (World Mercator) could not contain levels 1-4 and 8-12 because levels 4 and 8 are not adjacent levels. However, these two ranges of zoom levels could be in two distinct tile matrix sets: one set for zoom levels 1-4 and another set for zoom levels 8-12. Requirement /req/zoom/matrix-sets-multiple is not applicable to tile_matrix sets with a CRS that is not in [6] OGC 17-083r2.

Requirement 24	/req/zoom/matrix-sets-multiple ***If the GeoPackage tile matrix has more than one zoom level for a CRS in [6] OGC 17-083r2, the gpkg_tile_matrix table SHALL contain zoom levels that are in all or a subset of consecutive zoom levels in the tile matrix sets for the respective CRS defined in OGC 17-083r2 Annex D, TileMatrixSets.***

Requirement 25	/req/zoom/matrix-sets-one ***For a GeoPackage tile matrix set with only one zoom level, the gpkg_tile_matrix table SHALL contain a single tile matrix set for the scale of the product (e.g., 1:12,500, 1:50,000, 1:100,000).***

8.3 Bounding Boxes

This clause specifies how bounding boxes should be used to support the global tile indexing scheme that is specified in [6] OGC 2D Tile Matrix Set, 17-083r2, the 2D Tile Matrix Set.

Requirement 26	/req/bbox/crs ***The (min_x, min_y, max_x, max_y) values in the gpkg_tile_matrix_set table SHALL be within or equal to the maximum bounds of the CRS specified for the tile pyramid data table.***

As stated in [4] GeoPackage 1.3.1 section 1.1.3.1.1 Data, requirement 15, the bounding box (min_x, min_y, max_x, max_y) provides an *informative* bounding box of the content. In usage of the GeoPackage, the bounding box of the gpkg_tile_matrix_set provides the latitude and longitude extent that enables applications to determine the geographic position of each tile in the tile pyramid data table.

8.4 Tile Layer Metadata

This clause requires the storage of metadata as XML in GeoPackages, and specifies the use of particular metadata values in certain conditions per the DMF and optionally national metadata such as NMF.

The metadata in this section describes the individual layers of tiled imagery or other coverages contained in the GeoPackage. As stated in section 7.3 Requirement /req/metadata/product-partial, "If particular tables in a GeoPackage constitute separate data products in Table-29, then the component elements that describe those data products SHALL be in the metadata XML as shown in Table-30 . . . ." The columns in Table-29 are repeated as a row with a unique id value and md_scope of "model" for each tileSet, and md_scope of "tile" for each tile. This section gives an example of metadata that applies to Tile layers and tiles of raster and other coverage data contained in a GeoPackage.

While the Tile Metadata uses the same table structure as the comprehensive GeoPackage metadata, it does not contain a replica of the whole GeoPackage product metadata defined in section 7.3 Table-26. The fields listed in Table-33 are suggested in a tabular format (which would be represented in XML using DMF). The tileSet metadata use is optional and should be chosen as best suited to the contents of a particular tile Matrix Set layer or set of layers in the GeoPackage data product. Information about the tileSet layer that is contained within the GeoPackage (such as SRS) does not necessarily need to be in the metadata, though it can be repeated for clarity.

Table 33: gpkg_metadata.metadata Contents - Example TileSet Metadata

Field	Example
Abstract of the layer	Advanced Spaceborne Thermal Emission and Reflection Radiometer Version 2 Global Digital Elevation Model Color w/ Elevations, 1 arc-second Resolution
Keyword list	elevation, ASTER
CLASSIFICATION	UNCLASSIFIED
RELEASABILITY	REL NATO
Layer Update Date and Time	2019-05-15T01:43:45
SRS	EPSG:4326
Dimension name, units	elevation, meters
Dimension name, Extent	elevation, -600.0/9568.0/0
MAX scale	1:2000000
MIN scale	1:18000000
Legend	representation of the color legend

Requirement 27	/req/metadata/tile ***If a GeoPackage with raster tile data contains metadata, the GeoPackage shall use the table metadata to describe a tileSet or tile using the format defined in Table-29 and Table-30 with metadata the GeoPackage producer provides the contents of the tile data.***

9 Features

9.1 Feature Layer Metadata

This clause describes the storage of metadata as XML in GeoPackages and specifies the use of particular metadata values in certain conditions per the DMF and optionally national metadata such as NMF.

The metadata in this section describes the individual layers of Feature data in the SQLite database contained in the GeoPackage. As stated in section 7.3 Requirement /req/metadata/product-partial, "If particular tables in a GeoPackage constitute separate data products in Table-29, then the component elements that describe those data products SHALL be in the metadata XML as shown in Table-30 … ." This section gives an example of metadata that applies to Feature layers of vector data contained in a GeoPackage. Metadata for features and attributes of vector data can be defined using the same metadata construct.

While the Feature Metadata uses the same table structure as the comprehensive GeoPackage metadata, it does not contain a replica of the whole GeoPackage product metadata defined in section 7.3 Table-26. The fields listed in Table 34 are suggested in a tabular format (which would be represented in XML using DMF) based upon a fictitious example derived from the open-source Multi-national Geospatial Co-production Program (MGCP) World data. The specific Feature Type Metadata used is optional and should be chosen as best suited to the contents of a particular Feature layer or set of layers in the GeoPackage data product. Information about the Feature layer that is contained within the GeoPackage (such as SRS) does not necessarily need to be in the metadata, though it can be repeated for clarity.

Table 34: gpkg_metadata.metadata Contents - Example Feature Type Metadata

Field	Example
Abstract of the layer	Show a tract containing a concentration of buildings and/or other structures in Samoa, Kiribati, and Tonga.
Keyword list	geoscientificInformation
Category	Population
Data type	Vector polygon
CLASSIFICATION	UNCLASSIFIED
RELEASABILITY	REL NATO
Layer Update Date and Time	2015-03-25T01:43:45
Layer Temporal Extent (Date and Time range)	2015-03-25T00:00:00,2020-03-25T23:59:59
MAX scale intended use	1:10000

Field	Example
MIN scale intended use	1:100000
Portrayal standard	DGIWG 109, Portrayal Standard for MGCP

Requirement 28	/req/metadata/feature ***If a GeoPackage with Feature data contains metadata, the GeoPackage shall use the table metadata to describe a vector layer, feature, or feature attribute using the format in Table-29 and Table-30 with metadata the GeoPackage producer provides for the contents of the vector data.***

Annex A Abstract Test Suite for Conformance

A.1 Conformance Class OGC GeoPackage

Table A-1.1 ATS 1.1

Test identifier:	http://www.dgiwg.org/std/gpkg/1.0/conf/geopackage/base
Test purpose:	Verify that a DGIWG GeoPackage is conformant to the OGC Core Requirements in GPKG version 1.3.1 (http://www.geopackage.org/spec131/base/core/<ogc-test-name>)
Requirements:	/req/geopackage/base : OGC Core Requirements in GPKG section 1.1
Conformance Class:	Base
Test type:	Capability
Test method:	Validate DGIWG GeoPackage against OGC tests for OGC Core Requirements using [4] GPKG Annex A.1.1.

Table A-1.2 ATS 1.2

Test identifier:	http://www.dgiwg.org/std/gpkg/1.0/conf/geopackage/options
Test purpose:	Verify that a DGIWG GeoPackage is conformant to the OGC Optional Requirements in GPKG version 1.3.1 (http://www.geopackage.org/spec131/opt/features/<ogc-test-name>)
Requirements:	/req/geopackage/options : OGC Options Requirements in GPKG sections 2.1-2.4
Conformance Class:	Options
Test type:	Capability
Test method:	Validate DGIWG GeoPackage against OGC tests for OGC Optional Requirements using [4] GPKG Annex A.2.1 - A.2.4 for DGIWG mandatory, conditional, and optional GPKG extensions according to Table-8 in this GeoPackage.

A.2 Conformance Class Extensions

Table A-2.1 ATS 2.1

Test identifier:	http://www.dgiwg.org/std/gpkg/1.0/conf/extensions/mandatory
Test purpose:	Verify that a DGIWG GeoPackage is conformant to the Extension Mandated GPKG (http://www.dgiwg.org/std/gpkg/1.0/conf/extensions/mandatory)
Requirements:	/req/extensions/mandatory
Conformance Class:	extensions
Test type:	Capability
Test method:	Validate DGIWG GeoPackage contains mandatory extensions for http://www.dgiwg.org/std/gpkg/1.0/conf/extension/mandatory.

```
ATS returns Pass or Fail compliance for each extension for Features and for
Tiles.

If no extensions are mandatory in the GeoPackage profile, this ATS is null.

For each extension name _e_ in Table 7,
  If Table 7 Features column value for _e_ = "M" and any row of
gpkg_contents.data_type = "features", then
  Search rows of table gpkg_extension for _e_:
  If gpkg_extensions.extension_name contains _e_, then Pass for _e_ Vector;
End For
If no extension matched _e_, Fail for extension name _e_ Vector.

For each extension name _e_ in Table 7,
  If Table 7 Tiles column value for _e_ = "M" and any row of
gpkg_contents.data_type = "tiles", then
  Search rows of table gpkg_extension for _e_:
  If gpkg_extensions.extension_name contains _e_, then Pass for _e_ Tiles;
End For
If no extension matched _e_, Fail for extension name _e_ Tiles.
```

Table A-2.2 ATS 2.2

Test identifier:	http://www.dgiwg.org/std/gpkg/1.0/conf/extensions/optional
Test purpose:	Verify that a DGIWG GeoPackage is conformant to the Extension Optional GPKG (http://www.dgiwg.org/std/gpkg/1.0/conf/extensions/optional)

Requirements:	/req/extensions/optional
Conformance Class:	extensions
Test type:	Capability
Test method:	Validate extensions in DGIWG GeoPackage are optional for http://www.dgiwg.org/std/gpkg/1.0/conf/extensions/optional when the extension is applicable to the GeoPackage content. If no extensions are optional in the profile, this ATS is null.

```
ATS returns Pass or Fail compliance for each extension for Features and for
Tiles.
Returns NULL if no extensions are optional.

For each extension name _e_ in Table 7,
  If Table 7 Features value for _e_ = "0" and any row of
gpkg_contents.data_type = "features", Then
    Pass for extension name _e_ Features.
  End If
End For

For each extension name _e_ in Table 7,
  If Table 7 Tiles value for _e_ = "0" and any row of gpkg_contents.data_type
= "tiles", Then
    Pass for extension name _e_ Tiles.
  End If
End For

Note - If the extension is NA and present in GeoPackage, then the test fails
because this extension is not optional.

For each extension name _e_ in Table 7,
  If Table 7 Features value for _e_ = "NA" and any row of
gpkg_contents.data_type = "features", Then
    Search rows of table gpkg_extension for _e_ with a features extension.
    For each extension _e2_ in gpkg_extension
      If gpkg_extensions(_e2_).extension_name contains _e_,
      Then
        Fail if extension applies to features and features table exists in
geopackage.
        If gpkg_extensions(_e2_).table_name = NULL OR
gpkg_extensions(_e2_).table_name matches any gpkg_contents.table_name where
gpkg_contents.data_type = "features"
        Then Fail for _e_ Features;
```

```
      End If
    End For
  End If

  If Table 7 Tiles value for _e_ = "NA" and any row of
gpkg_contents.data_type = "tiles", Then
    Search rows of table gpkg_extension for _e_ with a tiles extension
    For each extension _e2_ in gpkg_extension
      If gpkg_extensions(_e2_).extension_name contains _e_,
      Then
        Determine if extension applies to tiles and tiles for this extension
exist in geopackage.
        If gpkg_extensions(_e2_).table_name = NULL OR
gpkg_extensions(_e2_).table_name matches any gpkg_contents.table_name where
gpkg_contents.data_type = "tiles"
        Then Fail for extension name _e_ Tiles;
        End If
    End For
  End If
End For
```

Table A-2.3 ATS 2.3

Test identifier:	http://www.dgiwg.org/std/gpkg/1.0/conf/extensions/not-allowed
Test purpose:	Verify that a DGIWG GeoPackage is conformant to the Extension Not Allowed GPKG (http://www.dgiwg.org/std/gpkg/1.0/conf/extensions/not-allowed)
Requirements:	/req/extensions/not-allowed
Conformance Class:	extensions
Test type:	Capability
Test method:	Validate that no extensions in DGIWG GeoPackage that are not allowed are implemented according to http://www.dgiwg.org/std/gpkg/1.0/conf/extensions/not-allowed. If no extensions are disallowed in the profile, this ATS is null.

```
ATS returns Pass or Fail compliance for each extension for Features and for
Tiles.

For each extension name _e_ in Table 7
  Check features extensions
  If Table 7 Features value for _e_ = "N" and any row of
gpkg_contents.data_type = "features"
  Then
    Search rows of table gpkg_extension for _e_:
    If gpkg_extensions.extension_name contains _e_, then Fail for extension
name _e_ Features;
  Else
    If no extension matched _e_, then Pass for extension name _e_ Features.
  End If

  Check tiles extensions
  If Table 7 Tiles value for _e_ = "N" and any row of gpkg_contents.data_type
= "tiles"
  Then
    If gpkg_extensions.extension_name contains _e_, then Fail for extension
name _e_ Tiles.
  Else
    If no extension matched _e_, then Pass for extension name _e_ Tiles.
  End If

End for
```

Table A-2.4 ATS 2.4

Test identifier:	http://www.dgiwg.org/std/gpkg/1.0/conf/extensions/conditional
Test purpose:	Verify that a DGIWG GeoPackage is conformant to the Extension Conditional GPKG (http://www.dgiwg.org/std/gpkg/1.0/conf/extensions/conditional)
Requirements:	/req/extensions/conditional
Conformance Class:	extensions
Test type:	Capability
Test method:	Validate extensions in DGIWG GeoPackage exist that meet conditional criteria for http://www.dgiwg.org/std/gpkg/1.0/conf/extensions/conditional. If no conditional extensions are required in the profile, this ATS is null.

```
ATS returns Pass or Fail compliance for each conditional extension for
Features and for Tiles; null if no extensions are conditional.

For each extension name _e_ in Table 7,
if Table 7 Features value for _e_ = "C" and any row of
gpkg_contents.data_type = "features", then
If gpkg_extensions.extension_name contains _e_, then Pass for extension name
_e_ Features; Else Null result.

For each extension name _e_ in Table 7,
if Table 7 Tiles value for _e_ = "C" and any row of gpkg_contents.data_type =
"tiles", then
If gpkg_extensions.extension_name contains _e_, then Pass for extension name
_e_ Tiles; Else Null result.
```

A.3 Conformance Class Coordinate Reference Systems

Table A-3.1 ATS 3.1

Test identifier:	http://www.dgiwg.org/std/gpkg/1.0/conf/crs/raster-allowed
Test purpose:	Verify that a DGIWG GeoPackage is conformant to the CRS GPKG (http://www.dgiwg.org/std/gpkg/1.0/conf/crs/raster-allowed)
Requirements:	/req/crs/raster-allowed
Conformance Class:	crs
Test type:	Capability
Test method:	Validate the Coordinate Reference Systems (CRS) in each Tile Matrix Set used in DGIWG GeoPackage complies with http://www.dgiwg.org/std/gpkg/1.0/conf/crs/raster-allowed.

```
ATS returns Pass or Fail compliance for each tile matrix set.

For each tile matrix set _t_ in gpkg_contents where the
gpkg_contents.data_type of _t_ = "tiles",
  If the srs_id of gpkg_tile_matrix_set for _t_ equals the corresponding
gpkg_spatial_ref_sys.srs_id,
  Set the default tile-matrix-set-CRS(_t_) to Pass.
  Then for this _srs_id_
    If the gpkg_spatial_ref_sys.srs_name of _srs_ does not match one of the
CRS in Table 11 or Table 12 that corresponds to the srs_name defined in
section 7.2 tables 14 through 21
    Then Fail for tile-matrix-set-CRS(_t_)
    End If
  End If
End For
```

Table A-3.2 ATS 3.2

Test identifier:	http://www.dgiwg.org/std/gpkg/1.0/conf/crs/raster-tile-matrix-set
Test purpose:	Verify that a DGIWG GeoPackage is conformant to the CRS GPKG for raster data (http://www.dgiwg.org/std/gpkg/1.0/conf/crs/raster-tile-matrix-set)
Requirements:	/req/crs/raster-tile-matrix-set
Conformance Class:	crs
Test type:	Capability

Test method:	Validate each tile matrix set contained in DGIWG GeoPackage follow the implementation for the respective CRS defined in [6] OGC 17-083r2 conformance class http://www.opengis.net/spec/tilematrixset/1.0/conf/crs-raster-tile-matrix-set.

```
ATS returns Pass or Fail compliance for each tile matrix set.

For each tile matrix set _t_ in gpkg_contents where the
gpkg_contents.data_type of _t_ = "tiles"
  If the srs_id of gpkg_tile_matrix_set _t_ equals the corresponding
gpkg_spatial_ref_sys.srs_id
  Then
    Set the default tile-matrix-set-conform(_t_) to Null.
    For this _srs_id_,
    If the gpkg_spatial_ref_sys.srs_name of _srs_ matches a srs_name in Table
14 through Table 21
    Then
      If the gpkg_tile_matrix_set of _t_ conforms to the XML or JSON_LD
encoding as verified by ATS A.1 - A.16 of [6] OGC 2D TMS 17-083r2
        AND the gpkg_tile_matrix_set for *each* zoom_level of _t_ matches the
well known scale set of the corresponding TileMatrixSet.ScaleDenominator of
the CRS with the same zoom level in Annex C.1, C.2, C.3, C.4, D.1, D.2, D.3,
or D.4 of [6] OGC 2D TMS 17-083r2
      Then Pass for tile-matrix-set-conform(_t_)
      Else Fail for tile-matrix-set-conform(_t_)
      End If
    Else
      Remains Null (This ATS does not apply)
    End If
  End If
End For
```

Table A-3.3 ATS 3.3

Test identifier:	http://www.dgiwg.org/std/gpkg/1.0/conf/crs/2d-vector
Test purpose:	Verify that a DGIWG GeoPackage is conformant to the CRS GPKG for 2D vector data (http://www.dgiwg.org/std/gpkg/1.0/conf/crs/2d-vector)
Requirements:	/req/crs/2d-vector
Conformance Class:	crs
Test type:	Capability

Test method:	Validate the 2D vector CRS used in each feature set in DGIWG GeoPackage complies with http://www.dgiwg.org/std/gpkg/1.0/conf/crs/2d-vector.

```
ATS returns Pass or Fail compliance for each 2D feature set; NULL if no
features are in GeoPackage.

For each feature set _f_ in gpkg_contents where the gpkg_contents.data_type
of _f_ = "features"
  Set the default Geometry-Columns-2D-CRS(_f_) to Pass.
  If the srs_id of gpkg_geometry_columns for _f_ equals the corresponding
gpkg_spatial_ref_sys.srs_id AND gpkg_geometry_column.z = 0
  Then
    For this _srs_id_,
    If the gpkg_spatial_ref_sys.srs_name of _srs_id_ does not match one of
the CRS with "CRS Dim" = 2  in Table 13
    Then Set Geometry-Columns-2D-CRS(_f_) to Fail for feature set _f_
    End If
  End If

  Set the default Geometry-Binary-CRS(_f_) to Pass.

  If the empty geometry flag for _f_ is not set AND the srs_id of
GeoPackageBinaryHeader for _f_ equals the corresponding
gpkg_spatial_ref_sys.srs_id
  Then
    For this _srs_id_,
    If the gpkg_spatial_ref_sys.srs_name of _srs_id_ does not match one of
the CRS in Table 13 that corresponds to the srs_name defined in section 7.2
tables 14 through 24
    Then Set Geometry-Binary-CRS(_f_) to Fail for feature set _f
    End If
  End If

  If Geometry-Binary-CRS(_f_) AND Geometry-Columns-2D-CRS(_f_) are both Pass
  Then Pass for feature set _f_
  Else Fail for feature set _f_
  End If
```

Table A-3.4 ATS 3.4

Test identifier:	http://www.dgiwg.org/std/gpkg/1.0/conf/crs/3d-vector
Test purpose:	Verify that a DGIWG GeoPackage is conformant to the CRS GPKG for 3D vector data (http://www.dgiwg.org/std/gpkg/1.0/conf/crs/3d-vector)

Requirements:	/req/crs/3d-vector
Conformance Class:	crs
Test type:	Capability
Test method:	Validate the 3D vector CRS used in DGIWG GeoPackage comply with http://www.dgiwg.org/std/gpkg/1.0/conf/crs/3d-vector.

```
ATS returns Pass or Fail compliance for each 3D feature set; NULL if no
features are in GeoPackage.

For each feature set _f_ in gpkg_contents where the gpkg_contents.data_type
of _f_ = "features"
  Set the default Geometry-Columns-3D-CRS(_f_) to Pass.
  If the srs_id of gpkg_geometry_columns for _f_ equals the corresponding
gpkg_spatial_ref_sys.srs_i AND gpkg_geometry_column.z != 0
  Then
    For this _srs_id_,
    If the gpkg_spatial_ref_sys.srs_name of _srs_id_ does not match one of
the CRS with "CRS Dim" = 3 or "CRS DIM" = 1 in Table 13
    Then Set Geometry-Columns-3D-CRS(_f_) to Fail for feature set _f_
    End If
  End If

  Set the default Geometry-Binary-CRS(_f_) to Pass.

  If the empty geometry flag for _f_ is not set AND the srs_id of
GeoPackageBinaryHeader for _f_ equals the corresponding
gpkg_spatial_ref_sys.srs_id
  Then
    For this _srs_id_,
    If the gpkg_spatial_ref_sys.srs_name of _srs_id_ does not match one of
the CRS in Table 13
    Then Set Geometry-Binary-CRS(_f) to Fail for feature set _f_
    End If
  End If

  If Geometry-Binary-CRS(_f_) AND Geometry-Columns-3D-CRS(_f_) are Pass,
  Then Pass for feature set _f_
  Else Fail for feature set _f_
  End If
End For
```

Table A-3.5 ATS 3.5

Test identifier:	http://www.dgiwg.org/std/gpkg/1.0/conf/crs/wkt
Test purpose:	Verify that a DGIWG GeoPackage is conformant to the CRS / SRS WKT GPKG (http://www.dgiwg.org/std/gpkg/1.0/conf/crs/wkt)
Requirements:	/req/crs/wkt
Conformance Class:	crs
Test type:	Capability
Test method:	Validate the CRS / SRS definition used in DGIWG GeoPackage contains WKT compliant with optional and mandatory elements appropriate for the CRS / SRS as defined by WKT1 [8] to comply with DGIWG GeoPackage http://www.dgiwg.org/std/gpkg/1.0/conf/crs/wkt.

```
ATS returns Pass or Fail compliance for each CRS in gpkg_spatial_ref_sys

For each crs _srs_id_ in gpkg_spatial_ref_sys
  Set default WKT-CRS for _srs_id_ to Pass.
  _wkt_def_ = gpkg_spatial_ref_sys.definition(srs_id)

  If _wkt_def_ does not contain "COMPOUNDCRS"
    Validate the _wkt_def_ is consistent with the WKT definition in Table 14
through Table 23 for the corresponding _srs_id_
    If _wkt_def_ is NOT valid for _srs_id_
    Then Set WKT-CRS for _srs_id_ to Fail
    Else
      _wkt_def_ = gpkg_spatial_ref_sys.definition_12_063(_srs_id_)
      If _wkt_def_ is not NULL
      Then
        Validate the _wkt_def_ is consistent with the WKT definition in Table
14 through Table 23 for the corresponding _srs_id_
        If _wkt_def_ is NOT valid for _srs_id_
        Then Set WKT-CRS for _srs_id_ to Fail
        End If
      End If
    End If
  End If
End For
```

Table A-3.6 ATS 3.6

Test identifier:	http://www.dgiwg.org/std/gpkg/1.0/conf/crs/compound
Test purpose:	Verify that a DGIWG GeoPackage is conformant to the Compound CRS GPKG Z (http://www.dgiwg.org/std/gpkg/1.0/conf/crs/compound)
Requirements:	/req/crs/compound
Conformance Class:	crs
Test type:	Capability
Test method:	Validate every compound CRS used in DGIWG GeoPackage contains Z geometry values to comply with DGIWG GeoPackage http://www.dgiwg.org/std/gpkg/1.0/conf/crs/compound. If Z doesn't exist (2D features), then the CRS cannot have a COMPOUNDCRS; if Z exists, COMPOUNDCRS is optional (e.g. could use EPSG 4979 instead of compound CRS).

```
ATS returns Pass or Fail compliance for each feature set

For each feature set _f_ in gpkg_contents where the gpkg_contents.data_type
of _f_ = "features"
  Set the default Geometry-Columns-Compound-CRS(_f_) to Pass.
  If the srs_id of gpkg_geometry_columns for _f_ equals the corresponding
gpkg_spatial_ref_sys.srs_id
  Then
    If gpkg_geometry_columns(_srs_id_).z = 0 (Z prohibited)
    Then
      For this _srs_id_,
      If the gpkg_spatial_ref_sys.definition(_srs_id_) or
definition_12_063(_srs_id_) for _srs_id_ contains "COMPOUNDCRS"
      Then set Geometry-Columns-Compound-CRS(_f_) to Fail for feature set
_f_.
    End If
  End If
End For.
```

Table A-3.7 ATS 3.7

Test identifier:	http://www.dgiwg.org/std/gpkg/1.0/conf/crs/compound-wkt
Test purpose:	Verify that a DGIWG GeoPackage is conformant to the Compound CRS WKT GPKG (http://www.dgiwg.org/std/gpkg/1.0/conf/crs/compound-wkt)
Requirements:	/req/crs/compound-wkt
Conformance Class:	crs
Test type:	Capability
Test method:	Validate every compound CRS used in DGIWG GeoPackage contains WKT compliant according to Table-25 with optional and mandatory elements appropriate for the CRS / SRS as defined by WKT1 [8] to comply with DGIWG GeoPackage http://www.dgiwg.org/std/gpkg/1.0/conf/crs-compound-wkt.

```
ATS returns Pass or Fail compliance for each CRS in gpkg_spatial_ref_sys

For each crs _srs_id_ in gpkg_spatial_ref_sys
  Set default COMPOUND-WKT-CRS for _srs_id_ to Pass.
  _wkt_def_ = gpkg_spatial_ref_sys.definition(srs_id)
  If _wkt_def_ contains "COMPOUNDCRS"
  Then
    Validate the _wkt_def_ contains the compound fields consistent with the
WKT definition for COMPOUNDCRS in Table 24 and Table 25
    If _wkt_def_ is NOT valid for _srs_id_
    Then Set COMPOUND-WKT-CRS for _srs_id_ to Fail
    Else
      _wkt_def_ = gpkg_spatial_ref_sys.definition_12_063(srs_id)
      If _wkt_def_ is not NULL
      Then
        If _wkt_def_ contains "COMPOUNDCRS"
        Then
          Validate the _wkt_def_ contains the compound fields consistent with
the WKT definition for COMPOUNDCRS in Table 24 and Table 25
          If _wkt_def_ is NOT valid for _srs_id_
          Then Set COMPOUND-WKT-CRS for _srs_id_ to Fail
          End If
        End If
      End If
    End If
  End If
End For.
```

A.4 Conformance Class Metadata

Table A-4.1 ATS 4.1

Test identifier:	http://www.dgiwg.org/std/gpkg/1.0/conf/metadata/dmf
Test purpose:	Verify that a DGIWG GeoPackage is conformant to contain metadata for the whole GPKG (http://www.dgiwg.org/std/gpkg/1.0/conf/metadata-dmf)
Requirements:	/req/metadata/dmf
Conformance Class:	metadata
Test type:	Capability
Test method:	Validate at least one whole data product metadata contains metadata in gpkg_metadata.metadata for each row of Table-26 that has a gpkg_metadata.md_scope of "dataset" and the required gpkg_metadata.metadata exists for the complete DGIWG GeoPackage to be compliant with http://www.dgiwg.org/std/gpkg/1.0/conf/metadata-dmf.

AND contains DMF for any other part of the GeoPackage.

```
ATS produces a validation result for the entire gpkg_metadata.

Set default Metadata-whole-dmf to Fail.
Set default Metadata-part-dmf to Fail.
partial-metadata = false

If ATS 1.2 for GeoPackage Metadata Extension F.8 Pass
Then continue to perform more specific validation of the gpkg_metadata
  For each row in gpkg_metadata with id _m_
    If gpkg_metadata.md_scope(_m_) is equal to "series" or "dataset"
      If gpkg_metadata(_m_).md_standard_id is a valid DMF URL
      Then
        Validate gpkg_metadata(_m_).metadata XML content with DMF ATS.
        dmf_valid = result of DMF ATS for a DMF Metadata Set [1] DGIWG
Metadata Foundation ATS A.4.

        If  dmf_valid is true
        Then Metadata-whole-dmf = Pass.
        End If
      End If
    Else
      Check if a part of the GeoPackage also contains DMF metadata
      If another metadata set exists, at least one must be in DMF.
```

```
      partial-metadata = true
      If gpkg_metadata(_m_).md_standard_id is a valid DMF URL
      Then
        Validate gpkg_metadata(_m_).metadata XML content with DMF ATS.
        dmf_valid = result of DMF ATS for a DMF Metadata Set [1] DGIWG
Metadata Foundation ATS A.4.

        If dmf_valid is true
        Then Metadata-part-dmf = Pass.
        End If

      End If
    End If
  End For
End If

If any part of the GeoPackage contains metadata, then both whole and part
must be valid DMF.

If partial_metadata is True
Then
  Return Metadata-whole-dmf AND Metadata-part-dmf
Else
  Return Metadata-whole-dmf
End If
```

Table A-4.2 ATS 4.2

Test identifier:	http://www.dgiwg.org/std/gpkg/1.0/conf/metadata/gpkg
Test purpose:	Verify that a DGIWG GeoPackage is conformant to contain metadata for the whole GPKG (http://www.dgiwg.org/std/gpkg/1.0/conf/metadata-gpkg)
Requirements:	/req/metadata/gpkg
Conformance Class:	metadata
Test type:	Capability
Test method:	Validate at least one whole data product metadata contains metadata in gpkg_metadata.metadata for each row of Table-26 that has a gpkg_metadata.md_scope of "dataset" and the required gpkg_metadata.metadata exists for the complete DGIWG GeoPackage to be compliant with http://www.dgiwg.org/std/gpkg/1.0/conf/metadata-gpkg.

```
ATS produces a validation result for the entire gpkg_metadata.

Set default Metadata-whole to Fail.

  For each row in gpkg_metadata with id _m_
    If gpkg_metadata.md_scope(_m_) is equal to "series" or "dataset"
    Then
      If gpkg_metadata.metadata(_m_) is not NULL AND
        gpkg_metadata(_m_).md_standard_id is not NULL and
        gpkg_metadata(_m_).mime_type = "text/xml"
      Then
        Metadata-whole = Pass.
      End If
    End If
  End For

Return Metadata-whole
```

Table A-4.3 ATS 4.3

Test identifier:	http://www.dgiwg.org/std/gpkg/1.0/conf/metadata/row
Test purpose:	Verify that a DGIWG GeoPackage metadata_reference table row is conformant to the metadata table structure for the whole GPKG (http://www.dgiwg.org/std/gpkg/1.0/conf/metadata-row)
Requirements:	/req/metadata/row
Conformance Class:	metadata
Test type:	Capability
Test method:	Validate each row of metadata in Table-26 have at least one corresponding row in metadata_reference in Table-28 for the whole GPKG in DGIWG GeoPackage to be compliant with http://www.dgiwg.org/std/gpkg/1.0/conf/metadata-row.

```
ATS produces a validation result for each row in gpkg_metadata for a DGIWG
GeoPackage, including user defined metadata and its association to the
metadata_reference table.

For each row in gpkg_metadata with id _m_
  Set default gpkg-reference-row(_m_) to Pass
 If gpkg_metadata(_m_).md_scope = "dataset" (geopackage) or "series"
(product)
 Then
  Select table_name, column_name, row_id_value, timestamp, md_parent_id from
gpkg_metadata_reference
  where gpkg_metadata_reference.md_file_id = _m_ AND
gpkg_metadata_reference.reference_scope = "table" OR "geopackage"

  Ensure all user defined values in a gpkg_metadata are linked to the
associated metadata_reference
  If result set is empty
  Then
    Set gpkg-reference-row(_m_) to Fail
  Else
    For each result in result set, verify expected values
      If table_name != NULL OR row_id_value != NULL OR time_stamp is invalid
timestamp
      Then
        Set gpkg-reference-row(_m_) to Fail
      End If
    End For
  Else
    Note: metadata for other md_scope values are not tested in this
requirement.
    Set gpkg-reference-row(_m_) to NULL
  End If
End For
```

Table A-4.4 ATS 4.4

Test identifier:	http://www.dgiwg.org/std/gpkg/1.0/conf/metadata/user
Test purpose:	Verify that a DGIWG GeoPackage with user defined metadata associates a row in a partial set of GeoPackage content in the metadata_reference table to have a metadata table in a GPKG (http://www.dgiwg.org/std/gpkg/1.0/conf/metadata-user)
Requirements:	/req/metadata/user

Conformance Class:	metadata
Test type:	Capability
Test method:	If optional partial metadata exists in the gpkg_metadata, validate metadata associated with each user-defined row of partial tile and feature metadata as defined in Table-29 for gpkg_metadata.md_scope of "featureType", "feature", "model" (tileSet). and "tile" to have a gpkg_metadata_reference.reference_scope as defined in Table-30 that adhere to the md_scope and reference_scope defined in Table-31 for the DGIWG GeoPackage to be compliant with http://www.dgiwg.org/std/gpkg/1.0/conf/metadata-user.

```
ATS produces a validation result for each tile_matrix_set, tile_matrix,
geometry_columns and feature_geometry in gpkg_contents; Pass if metadata
tables are valid, Fail if metadata tables are invalid, NULL if no metadata
exists (it is optional)

** TILES **

For each tile matrix set _t_ in gpkg_contents where the
gpkg_contents.data_type of _t_ = "tiles"
  Set default Metadata-user-tile-set(_t_) to Null

  For each gpkg_metadata_reference where gpkg_metadata_referenc.table_name =
tile_matrix_set.table_name _t_  and gpkg_metadata_reference.row_id_value is
NULL

    This tile_matrix_set has 1 or more instances of metadata, search all tile
metadata_reference instances to have correct reference_scope and
corresponding gpkg_metadata.md_scope of "model"

    If the gpkg_metadata_reference.reference_scope = "table" for table_name
_t_ and row_id = NULL
    Then
      Does the gpkg_metadata exist for the gpkg_metadata_reference describing
this tile_matrix_set ?

      If exists gpkg_metadata_reference for table_name = _t_ and md_file_id
equal to 1 or more rows equal to gpkg_metadata.id where
gpkg_metadata.md_scope = "model"
      Then Set Metadata-user-tile-set(_t_) to Pass
      Else Set Metadata-user-tile-set(_t_) to Fail  (no metadata exists)
      End If
```

```
    Else
      Set Metadata-user-tile-set(_t_) to Fail (wrong reference scope for
tile_matrix_set)
    End If
  End For

  Next Search the tile_matrix pyramid tiles for tile metadata

  For each gpkg_metadata_reference where gpkg_metadata_reference.table_name =
tile_matrix.table_name _t_ and gpkg_metadata_reference.row_id value is not
NULL

    Set all default Metadata-user-tile(_t_,1 to max_zoom) to Null

    This tile has metadata, search all tile metadata_reference instances to
have correct reference_scope and corresponding gpkg_metadata.md_scope of
"tile" and the matching md_file_id value

    For each pyramid tile gpkg_tile_matrix _z_ where
gpkg_tile_matrix.zoom_level = metadata_reference.row-id AND
gpkg_metadata_reference.table_name = _t_

      If the gpkg_metadata_reference.reference_scope  = "row/col" for
table_name _t_ and row_id = _z_
      Then
        Does the gpkg_metadata exist for the gpkg_metadata_reference
describing this tile ?
        If exists gpkg_metadata_reference for _t_ and _z_ with md_file_id
equal to 1 or more rows equal to gpkg_metadata.id where
gpkg_metadata.md_scope = "tile"
        Then Set Metadata-user-tile(_t_,_z_) to Pass
        Else Set Metadata-user-tile(_t_,_z_) to Fail  (no metadata exists for
tile)
        End If
      Else
        Set Metadata-user-tile(_t_,_z_) to Fail (wrong reference scope for
tile)
      End If
    End For
  End For
End For

** FEATURES **

For each feature set _f_ in gpkg_contents where the gpkg_contents.data_type
```

```
of _f_ = "features"
  Set default Metadata-user-feature-set(_f_) to Null

  For each feature_geometry _f_ in gpkg_geometry_columns where
gpkg_geometry_columns.table_name = gpkg_metadata_reference.table_name and
gpkg_metadata_reference.row_id_value is NULL

    For each gpkg_metadata_reference where gpkg_metadata_referenc.table_name
= gpkg_geometry_columns.table_name _t_  and
gpkg_metadata_reference.row_id_value is NULL

      Search all feature sets with metadata to have correct reference_scope
and gpkg_metadata

      If gpkg_metadata_reference.reference_scope = "table" for table_name =
_f_ and row_id = NULL
      Then
        If exists gpkg_metadata_reference for table _f_ with md_file_id equal
to 1 or more rows equal to gpkg_metadata.id where gpkg_metadata.md_scope =
"featureType"
        Then Set Metadata-user-feature-set(_f_) to Pass
        Else Set Metadata-user-feature-set(_f_) to Fail  (no metadata exists)
        End If
      Else
        Set Metadata-user-feature-set(_f_) to Fail (wrong reference_scope)
      End If
    End For
  End For

  Next Search the feature_geometry for feature metadata

  For each gpkg_metadata_reference where gpkg_metadata_reference.table_name =
geometry_columns.table_name _f_ and gpkg_metadata_reference.row_id value is
not NULL

    Set all default Metadata-user-features(_f_,1 to max) to Null

    This tile has metadata, search all tile metadata_reference instances to
have correct reference_scope and corresponding gpkg_metadata.md_scope of
"tile" and the matching md_file_id value

    For each feature id _fid_ in geometry_columns.table_name _f_ where
geometry_columns.table_name.id = metadata_reference.row-id AND
gpkg_metadata_reference.table_name = _f_
```

```
      If the gpkg_metadata_reference.reference_scope = "row"  and row_id =
_fid_
      Then
        Does the gpkg_metadata exist for the gpkg_metadata_reference
describing this feature ?
        If exists gpkg_metadata_reference for _f_ and _fid_ with md_file_id
equal to 1 or more rows equal to gpkg_metadata.id where
gpkg_metadata.md_scope = "feature"
        Then Set Metadata-user-tile(_f_,_fid_) to Pass
        Else Set Metadata-user-tile(_f_,_fid_) to Fail  (no metadata exists
for feature)
        End If
      Else
        Set Metadata-user-tile(_f_,_z_) to Fail (wrong reference scope for
feature)
      End If
    End For
  End For
End For
```

Table A-4.5 ATS 4.5

Test identifier:	http://www.dgiwg.org/std/gpkg/1.0/conf/metadata/product
Test purpose:	Verify that a DGIWG GeoPackage is conformant to the Metadata Product GPKG (http://www.dgiwg.org/std/gpkg/1.0/conf/metadata/product)
Requirements:	/req/metadata/product
Conformance Class:	metadata
Test type:	Capability
Test method:	If a gpkg-metadata contains metadata for a series of products, validate gpkg product metadata contains metadata in gpkg_metadata.metadata with each row of Table-26 that has a gpkg_metadata.md_scope of "series", then the required gpkg_metadata.metadata exists for the gpkg product for the DGIWG GeoPackage to be compliant with http://www.dgiwg.org/std/gpkg/1.0/conf/metadata/product.

```
ATS produces a validation result for the entire gpkg_metadata if product
metadata is present and DMF compliant; NULL if no product metadata present.,

Set default Metadata-product-dmf to NULL.
Set default Metadata-product-other to NULL.
```

```
  For each row in gpkg_metadata with id _m_
    If gpkg_metadata.md_scope(_m_) is equal to "series"
      If gpkg_metadata(_m_).md_standard_id is a valid DMF URL
      Then
        Validate gpkg_metadata(_m_).metadata XML content with DMF ATS.
        dmf_valid = result of DMF ATS for a DMF Metadata Set [1] DGIWG
Metadata Foundation ATS A.4.

        If  dmf_valid is true
        Then Set Metadata-product-dmf to Pass.
        Else
          Set Metadata-product-dmf to Fail.
        End If
      Else
        Check if national metadata is populated for product.
        If gpkg_metadata.metadata(_m_) is not NULL AND
          gpkg_metadata(_m_).md_standard_id is not NULL and
          gpkg_metadata(_m_).mime_type = "text/xml"
        Then
          Set Metadata-whole-other to Pass.
        Else
          Set Metadata-whole-other to Fail.
        End If
      End If
    End If
  End For
End If

If any part of the GeoPackage contains metadata, then both whole and part
must be valid DMF.

If Metadata-product-dmf is not NULL
Then
  If Metadata-whole-other is not null
  Then
    Return Metadata-product-dmf AND Metadata-product-other
  Else
    Return Metadata-product-dmf.
Else
  Return NULL
End If
```

Table A-4.6 ATS 4.6

Test identifier:	http://www.dgiwg.org/std/gpkg/1.0/conf/metadata/product-partial
Test purpose:	Verify that a DGIWG GeoPackage with a partial set of metadata is conformant to the Metadata Partial GPKG (http://www.dgiwg.org/std/gpkg/1.0/conf/metadata/partial)
Requirements:	/req/metadata/product-partial
Conformance Class:	metadata
Test type:	Capability
Test method:	If optional metadata for a product (md_scope of 'series') in Table-29 exists in gpkg_metadata.metadata, verify that each row of metadata associated with the gpkg_metatdata_reference.md_parent_id in Table-30 has gpkg_metadata_reference.reference_scope value of "featureType", "tileSet", "feature", "attributeType", "attribute", or "tile" for a DGIWG GeoPackage to be compliant http://www.dgiwg.org/std/gpkg/1.0/conf/metadata/product-partial.

```
ATS produces a validation result for each row of the gpkg_metadata_reference.
Valid if partial metadata for a product is present; invalid if non-partial
metadata for a product exists; NULL if the gpkg_metadata_reference is not for
a product,

For each _r_ in gpkg_metatdata_reference
  Set default Metadata-product-partial(_r_) to NULL.
  parent_id = gpkg_metatdata_reference(_r_).md_parent_id
  If parent_id is not NULL
  Then
    This metadata reference is part of a hierarchy of metadata.

    md_file_id = gpkg_metatdata_reference(_r_).md_file_id
    If md_file_id != NULL
    Then
      If md_file_id != parent_id
      Then
        Since this gpkg_metadata_reference row is not the root of a metadata
hierarchy, determine if the metadata row of the parent_id is a product.

        If gpkg_metadata(parent_id).md_scope = "series"
        Then
          If the parent of the metadata is a series (product), then this
metadata record shall be a dataset or partial metadata content to be valid.

          If gpkg_metatdata_reference(_r_).reference_scope = "table" OR
"row/col" OR "row" OR "column"
          Then
            Set Metadata-product-partial(_r_) to Pass.
          Else
            Set Metadata-product-partial(_r_) to Fail.
          End If
        Else
          The md_parent_id cannot be equal to the md_file_id (See Annex F.8
Req 102), so this reference row fails.
          Set Metadata-product-partial(_r_) to Fail.
        End If
      End If
    Else (md_file_id is NULL, which is invalid)
      Set Metadata-product-partial(_r_) to Fail.
    End If
  End If
End For
```

Table A-4.7 ATS 4.7

Test identifier:	http://www.dgiwg.org/std/gpkg/1.0/conf/metadata/tile
Test purpose:	Verify that a DGIWG GeoPackage is conformant to the Tile Metadata GPKG (http://www.dgiwg.org/std/gpkg/1.0/conf/metadata/tile)
Requirements:	/req/metadata/tile
Conformance Class:	metadata
Test type:	Capability
Test method:	Validate the tile layer metadata in DGIWG GeoPackage to be compliant with http://www.dgiwg.org/std/gpkg/1.0/conf/metadata/tile.

```
ATS produces a validation result for each row of tile matrix set or tile
metadata in the gpkg_metadata table; null for those metadata that are not
tile matrix sets or tiles.

For each row in gpkg_metadata with id _m_
  Set default Metadata-tile(_m_) to NULL.
  partial-tile-metadata = false
  If gpkg_metadata.scope(_m_) is equal to "model" or "tile"
  Then
    partial-tile-metadata = true
    If gpkg_metadata(_m_).md_standard_id is a valid URL AND
gpkg_metadata(_m_).metadata is XML content AND gpkg_metadata(_m_).mime_type =
"text/xml"
    Then
      Check the gpkg_metadata_reference table row exists for this
gpkg_metadata row.

      For each reference_scope, table_name, column_name, row_id from
gpkg_metadata_reference.md_file_id = _m_

        If results are not empty result set
        Then
          If reference_scope = "table" (for md_scope ="model")
          Then
            If table_name exists in gpkg_tile_matrix_set
            Then
              Set Metadata-tile(_m_) to Pass
            Else
              Set Metadata-tile(_m_) to Fail
            End If
```

```
          Else
            If reference_scope = "row/col" (for md_scope of "tile")
              If table_name exists in gpkg_tile_matrix
              Then
                Set Metadata-tile(_m_) to Pass
              Else
                Set Metadata-tile(_m_) to Fail
              End If
            Else
              Set Metadata-tile(_m_) to Fail (invalid reference_scope)
            End If
          End If

        End If
      End For
    End If
  End If

  If partial-tile-metadata is True
  Then
    Verify the "attributeType" or "attribute" in gpkg_metadata_reference.

    Repeat the results of the GPKG Options ATS for Requirement 119 and the
ATS for the Metadata Extension Annex F.8 Requirements 96-99. These ATS
validate the column_name and row_id of tile attributes in
gpkg_metadata_reference correspond to the tables. columns and row values in
gpkg_contents, gpkg_tile_matrix_set, gpkg_tile_matrix and pyramid tiles for
the tile_matrix_set.
  End If
End For
```

Table A-4.8 ATS 4.8

Test identifier:	http://www.dgiwg.org/std/gpkg/1.0/conf/metadata/feature
Test purpose:	Verify that a DGIWG GeoPackage is conformant to the Vector Metadata GPKG (http://www.dgiwg.org/std/gpkg/1.0/conf/metadata/feature)
Requirements:	/req/metadata/feature
Conformance Class:	metadata
Test type:	Capability
Test method:	Validate Vector (feature) layer metadata in DGIWG GeoPackage to be compliant with http://www.dgiwg.org/std/gpkg/1.0/conf/metadata/feature.

```
ATS produces a validation result for each row of feature metadata in the
gpkg_metadata table; null for those metadata that are not feature data sets
or features.

For each row in gpkg_metadata with id _m_
  Set default Metadata-feature(_m_) to NULL.
  partial-feature-metadata = false
  If gpkg_metadata.md_scope(_m_) is equal to "featureType" or "feature" or
"attributeType" or "attribute"
  Then
    partial-feature-metadata = true
    If gpkg_metadata(_m_).md_standard_id is a valid URL AND
gpkg_metadata(_m_).metadata is XML content AND gpkg_metadata(_m_).mime_type =
"text/xml"
    Then
      Check the gpkg_metadata_reference table row exists for this
gpkg_metadata row.

      For each reference_scope, table_name, column_name, row_id from
gpkg_metadata_reference.md_file_id = _m_

        If results are not empty result set
        Then
          If reference_scope = "table" or "row" (for md_scope ="featureType")
          Then
            If table_name exists in gpkg_contents where
gpkg_contents.data_type = 'features' AND table_name exists in
gpkg_geometry_columns
            Then
              Set Metadata-feature(_m_) to Pass
            Else
              Set Metadata-feature(_m_) to Fail
            End If

          Else If reference_scope = "row" (for md_scope = "feature")
            If table_name exists in gpkg_contents where
gpkg_contents.data_type = 'features' AND table_name exists in
gpkg_geometry_columns
            Then
              Check that the feature exists in the feature table
              If table_name.row_id equals gpkg_metadata_reference.row_id
where gpkg_metadata_reference.md_file_id = _m_
              Then
                Set Metadata-feature(_m_) to Pass
```

```
              Else
                Set Metadata-feature(_m_) to Fail
              End If
            Else
              Set Metadata-feature(_m_) to Fail
            End If
          End If
        End If
      End For
    End If
  End If

  If partial-feature-metadata is True
  Then
    Verify the "attributeType" or "attribute" in gpkg_metadata_reference.

    Repeat the results of the GPKG Options ATS for Requirement 119 and the
ATS for the Metadata Extension Annex F.8 Requirements 96-99. These ATS
validate the column_name and row_id of tile attributes in
gpkg_metadata_reference correspond to the tables. columns and row values in
gpkg_contents, gpkg_geometry_columns, gpkg_geometry and feature table for the
feature data set.
  End If
End For
```

A.5 Conformance Class Validity

Table A-5.1 ATS 5.1

Test identifier:	http://www.dgiwg.org/std/gpkg/1.0/conf/validity/data-validity/ref-sys
Test purpose:	Verify that a DGIWG GeoPackage is conformant to the Validity constraints for specific fields in GPKG (http://www.dgiwg.org/std/gpkg/1.0/conf/validity/data-validity/ref-sys)
Requirements:	/req/validity/data-validity, rows 1-5
Conformance Class:	validity
Test type:	Capability
Test method:	Validate the DGIWG GeoPackage table and column values to be compliant with the value constraints for CRS in Table-32 rows 1-5 for http://www.dgiwg.org/std/gpkg/1.0/conf/validity/data-validity/ref-sys.

```
ATS produces a validation result of each crs in gpkg_spatial_ref_sys.

For each _srs_id_ in gpkg_spatial_ref_sys, test the following:
  If gpkg_spatial_ref_sys(_srs_id_) columns .organization, .description,
.definition, .definition_12-063 are consistent with the rules in Table 32
rows 1-5,
  Then Pass for gpkg_spatial_ref_sys(_srs_id_) srs_name;
  Else Fail for gpkg_spatial_ref_sys(_srs_id_) srs_name.
End For
```

Table A-5.2 ATS 5.2

Test identifier:	http://www.dgiwg.org/std/gpkg/1.0/conf/validity/data_validity/contents
Test purpose:	Verify that a DGIWG GeoPackage is conformant to the Validity constraints for specific fields in GPKG (http://www.dgiwg.org/std/gpkg/1.0/conf/validity/data-validity/contents)
Requirements:	/req/validity/data-validity, rows 6-10
Conformance Class:	validity
Test type:	Capability
Test method:	Validate the DGIWG GeoPackage table and column values to be compliant with the value constraints for content validity in Table-32 rows 6-10 for http://www.dgiwg.org/std/gpkg/1.0/conf/validity/data-validity/contents.

```
ATS produces a validation result of each data set table in gpkg_contents.

For each dataset _d_ in gpkg_contents, test the following:
  If gpkg_contents(_d_) columns .data_type, min_x, min_y, max_x, max_y are
consistent with the rules in Table 32 rows 6-10,
  Then Pass for gpkg_contents(_d_).table_name
  Else Fail for gpkg_contents(_d_).table_name
End For
```

Table A-5.3 ATS 5.3

Test identifier:	http://www.dgiwg.org/std/gpkg/1.0/conf/validity/data-validity/geometry
Test purpose:	Verify that a DGIWG GeoPackage table and column values to be compliant with the value constraints for the geometry values in Table-32 rows 11-14 for (http://www.dgiwg.org/std/gpkg/1.0/conf/validity/data-validity/geometry)
Requirements:	/req/validity-data-validity, rows 11-14
Conformance Class:	validity
Test type:	Capability
Test Method:	ATS produces a validation result of each feature set in gpkg_geometry_columns.

```
ATS returns Pass or Fail compliance for each feature set table in
geometry_columns; NULL if no features are in GeoPackage.

For each feature set _f_ in gpkg_geometry_columns, test the following:
  If gpkg_geometry_columns(_f_) .z, .table_name (feat_table) are consistent
with the rules in Table 32 rows 11-14
  Then Pass for gpkg_geometry_columns(_f_).table_name
  Else Fail for gpkg_geometry_columns(_f_).table_name
  End If
End For

The test for z = 0 and z = 1 are similar to ATS 3.6.
```

Table A-5.4 ATS 5.4

Test identifier:	http://www.dgiwg.org/std/gpkg/1.0/conf/validit/data-validity/constraint
Test purpose:	Verify that a DGIWG GeoPackage is conformant to the Validity constraints for specific fields in GPKG (http://www.dgiwg.org/std/gpkg/1.0/conf/validity/data-validity/constraint)
Requirements:	/req/validity/data-validity row 15
Conformance Class:	validity
Test type:	Capability
Test method:	Validate the DGIWG GeoPackage table and column values to be compliant with the value constraints for the data column constraint name in Table-32 row 15 for\http://www.dgiwg.org/std/gpkg/1.0/conf/validity/data-validity/constraint.

```
ATS produces a validation result of each row in gpkg_data_columns and each
constraint for a column.

For each column _col_ in gpkg_data_columns,
    If constraint_name for _col_ is not NULL and has mixed case or all
lowercase values,
    Then Pass for gpkg_data_columns(_col_).constraint_name
    Else Fail for gpkg_data_columns(_col_).constraint_name
End For

For each constraint _con_ in gpkg_data gpkg_data_columns_constraints
  If constraint_name for _con_ is  not NULL and has mixed case or all
lowercase values,
  Then Pass for gpkg_data_columns_constraints(_con_).constraint_name
  Else Fail for gpkg_data_columns_constraints(_con_).constraint_name
End For

Note: this requirement's ATS overrides the Requirement 106 in Extension F.9,
Schema, ATS /extensions/schema/data_columns/constraint_name.
```

Table A-5.5 ATS 5.5

Test identifier:	http://www.dgiwg.org/std/gpkg/1.0/conf/validity/data-validity/tile-matrix
Test purpose:	Verify that a DGIWG GeoPackage (http://www.dgiwg.org/std/gpkg/1.0/conf/validity/data-validity/tile-matrix)
Requirements:	/req/validity/data-validity 16-21
Conformance Class:	validity
Test type:	Capability
Test method:	Validate the DGIWG GeoPackage table and column values to be compliant with the value constraints for tile matrix definition in Table-32 rows 16-21 for http://www.dgiwg.org/std/gpkg/1.0/conf/validity/data-validity/tile-matrix. The compliance test uses results of ATS 4.2 to validate tile matrix sets in [6] OGC 17-083r2.

```
ATS produces a validation result of each row in gpkg_tile_matrix_set.

For each tile matrix set _t_ in gpkg_contents where the
gpkg_contents.data_type of _t_ = "tiles",
  If ATS 4.2 is Pass for _t_
  Then Pass this ATS for tile_matrix_set _t_
  Else verify the validity constraints Table 32 rows 16-21 are met for a
tile_matrix_set that is not defined in [6] OGC 17-083r2
     Verify zoom_level constraint <= max zoom in table.
     verify tile_width & tile_height = 256  (same as requirements 21 & 22,
ATS 7.1)
     Verify pixel_x_size, pixel_y_size to be factor of 2 (same as requirement
23, ATS 8.1)
     Verify pyramid-table_name zoom_level constraint <= max zoom in table.
  End If
End For
```

Table A-5.6 ATS 5.6

Test identifier:	http://www.dgiwg.org/std/gpkg/1.0/conf/validity/data-validity/metadata
Test purpose:	Verify that a DGIWG GeoPackage is conformant to the Validity constraints for specific fields in GPKG (http://www.dgiwg.org/std/gpkg/1.0/conf/validity/data-validity/metadata)
Requirements:	/req/validity-data-validity rows 22-30
Conformance Class:	validity
Test type:	Capability
Test method:	Validate the DGIWG GeoPackage table and column values to be compliant with the value constraints for the metadata definition in Table-321 rows 22-30 for http://www.dgiwg.org/std/gpkg/1.0/conf/validity/data-validity/metadata. Uses portions of the ATS for Extension F.8, Metadata.

```
ATS produces a validation result of each row in gpkg_metadata, including its
contents and rows in gpkg_metadata_reference associated with each
gpkg_metadata row.

If ATS 1.2 for GeoPackage Extension F.8 Pass
Then continue to perform more specific validation of the gpkg_metadata and
gpkg_metadata_reference tables.
For each row in gpkg_metadata with id _m_
  Set default Metadata-gpkg(_m_) to Pass.
  If _m_ is unique in gpkg_metadata table
    Validate table for _m_ using [4] GPKG F.8 ATS
/extensions/metadata/table_def
    If GPKG F.8 ATS /extensions/metadata/table_def for _m_ Fail, then set
Metadata-gpkg(_m_) to Fail.
    Else
      If [ gpkg_metadata(_m_).md_scope is equal to an integer value
corresponding to the values in Table 31
        AND gpkg_metadata(_m_).md_standard_id is a valid DMF URL or URL for
national metadata
        AND gpkg_metadata(_m_).mime_type = "text/xml" ]
      Then
        If gpkg_metadata(_m_).md_standard_id is a valid DMF URL Then
          Validate gpkg_metadata(_m_).metadata XML content
          Metadata-XML(_m_) = result of DMF ATS for a DMF Metadata Set [1]
DGIWG Metadata Foundation ATS A.4.
  Note: DMF metadata validation same as ATS 5.1.
        Else
```

```
          Note - use national ATS for national metadata validation.
          If ATS exists for national metadata,
          Then Metadata-XML(_m_) = result of ATS for national metadata.
          Else Metadata-XML(_m_) is Fail.
        End If
        Metadata-gpkg(_m_) = Metadata-XML(_m_) (result of metadata XML
validation for _m_)
      Else
        Set Metadata-gpkg(_m_) to Fail.
      End If

Check the other metadata validation in GPKG extension F.8.

      If Metadata-gpkg(_m_) is Pass AND
        IF any of the GPKG F.8 gpkg_metadata validity are False
        Then Set Metadata-gpkg(_m_) to Fail.
        Else

ATS continues to validate gpkg_metadata_reference if Metadata-gpkg(_m_) is
Pass from previous tests
          Validate gpkg_metadata_reference table for _m_ in [4] GPKG F.8 ATS
/extensions/metadata_reference/table_def .
          If GPKG F.8 ATS /extensions/metadata/table_def for _m_ Fail, then
set Metadata-gpkg(_m_) to Fail.
Table is valid, validate contents of each gpkg_metadata_reference for _m_
          Then
            For each row in gpkg_metadata_reference with md_file_id = _m_
              Validate every field in rows using [4] GPKG F.8 ATS
/extensions/metadata/metadata_reference/
              If GPKG F.8 ATS extensions/metadata/metadata_reference/ Fail
for _m_ and metadata_reference.md_file_id
              Then set Metadata-gpkg(_m_) to Fail.
            End for
          End If
        End If
      End If
    End If
  Else
    _m_ is not unique, set Metadata-gpkg(_m_) to Fail.
  End If
End For
```

A.6 Conformance Class Tile Matrix Set

Table A-6.1 ATS 6.1

Test identifier:	http://www.dgiwg.org/std/gpkg/1.0/conf/tile/size-matrix
Test purpose:	Verify that a DGIWG GeoPackage is conformant to the Tile Matrix Size GPKG (http://www.dgiwg.org/std/gpkg/1.0/conf/tile/size-matrix)
Requirements:	/req/tile/size-matrix
Conformance Class:	tile-matrix-set
Test type:	Capability
Test method:	Validate the tile matrix size in DGIWG GeoPackage has width and height value equal to 256 to be compliant with http://www.dgiwg.org/std/gpkg/1.0/conf/tile/size-matrix.

```
ATS produces a validation result of each row in gpkg_tile_matrix_set. If any
pyramid tile set fails, the entire tile_matrix_set fails.

For each tile matrix set _t_ in gpkg_contents where the
gpkg_contents.data_type of _t_ = "tiles",
  Set default Tile_Matrix_Set-size(_t_) to Pass.

  If ATS 4.2 is Fail or Null for _t_
  Then
    Verify the Pyramid tile matrix size is valid for a tile_matrix_set that
is not defined in [6] OGC 17-083r2 (ATS 4.2 Fail for _t_)
    For each pyramid tile _z_ in gpkg_tile_matrix
      If tile_width != 256 or tile_height != 256 for _z_ Then Set
Tile_Matrix_Set-size(_t_) to Fail.
    End For
  Else
    Set Tile_Matrix_Set-size(_t_) to Fail.
  End If
End For
```

Table A-6.2 ATS 6.2

Test identifier:	http://www.dgiwg.org/std/gpkg/1.0/conf/tile/size-data
Test purpose:	Verify that a DGIWG GeoPackage is conformant to the Tile Size GPKG (http://www.dgiwg.org/std/gpkg/1.0/conf/tile/size-data)

Requirements:	/req/tile/size-data
Conformance Class:	tile
Test type:	Capability
Test method:	Validate every pyramid data tile in DGIWG GeoPackage has width and height value equal to 256 to be compliant with http://www.dgiwg.org/std/gpkg/1.0/conf/tile/size-data.

```
ATS produces a validation result of each row in gpkg_tile_matrix_set. If any
data tile fails, the entire tile_matrix_set fails.

For each tile matrix set _t_ in gpkg_contents where the
gpkg_contents.data_type of _t_ = "tiles",
  Set default Tile_Matrix_Set-data_size(_t_) to Pass.
  If <<ATS-ref_test09,ATS 3.2>> is Fail or Null for _t_
  Then
    Verify the Table data size in the Pyramid tile matrix size is valid for a
gpkg_tile_matrix_set that is not defined in [6] OGC 17-083r2 (ATS 4.2 Fail)
        For each pyramid tile _z_ in gpkg_tile_matrix
          For each data tile _d_ in gpkg_tile_matrix(_z_).table_name
            If width of gpkg_tile_matrix(_z_).table_name.tile_data(_d_) !=
256 Then Set Tile_Matrix_Set-data_size(_t_) to Fail.
            If height of gpkg_tile_matrix(_z_).table_name.tile_data(_d_) !=
256 Then Set Tile_Matrix_Set-data_size(_t_) to Fail.
          End For
        End For
  End If
End For
```

A.7 Conformance Class Zoom

Table A-7.1 ATS 7.1

Test identifier:	http://www.dgiwg.org/std/gpkg/1.0/conf/zoom/factor
Test purpose:	Verify that a DGIWG GeoPackage is conformant to the Zoom levels for GPKG (http://www.dgiwg.org/std/gpkg/1.0/conf/zoom/factor)
Requirements:	/req/zoom/factor
Conformance Class:	zoom
Test type:	Capability
Test method:	Validate every zoom pixel size in DGIWG GeoPackage to be compliant with http://www.dgiwg.org/std/gpkg/1.0/conf/zoom/factor.

```
ATS produces a validation result of each row in gpkg_tile_matrix_set. If any
zoom level fails, the entire tile_matrix_set fails.

Case 1: gpkg_tile_matrix_set is consistent with [6] OGC 17-083r2, which has
zoom levels in factors of 2. Verify all consecutive zoom levels are adjacent.

For each tile matrix set _t_ in gpkg_contents where the
gpkg_contents.data_type of _t_ = "tiles",
  Set default Tile_Matrix_Set-size(_t_) to Pass.
  If ATS 4.2 is Pass for _t_
  Then
    For each zoom_level _z_ in gpkg_tile_matrix, starting at z = 1
      If zoom level _z_ is not an adjacent zoom level to (_z_ - 1)
      Then Set Tile_Matrix_Set-zoom(_t_) to Fail
      End If
    End For
  Else
    Set Tile_Matrix_Set-data_zoom(_t_) to Fail.
  End If

Case 2: gpkg_tile_matrix_set zoom levels defined in gpkg_tile_matrix; zoom
factor 2.0 within 1/100.

  Else
    Assumes first level of gpkg_tile_matrix is p = 1.
    For each zoom_level _z_ in gpkg_tile_matrix, starting at z = 1
      If [pixel_x_size(_z_-1) / pixel_x_size(_z_)] = 2.0 within 1/100 and
[pixel_y_size(_z_-1)/pixel_y_size(_z_)] = 2.0 within 1/100
      Then Set Tile_Matrix_Set-size(_t_) to Fail.
      End If
    End For
  End If

End For
```

Table A-7.2 ATS 7.2

Test identifier:	http://www.dgiwg.org/std/gpkg/1.0/conf/zoom/matrix-sets-multiple
Test purpose:	Verify that a DGIWG GeoPackage is conformant to the Matrix Sets GPKG (http://www.dgiwg.org/std/gpkg/1.0/conf/zoom/matrix-sets-multiple)
Requirements:	/req/zoom/matrix-sets-multiple

Conformance Class:	zoom
Test type:	Capability
Test method:	Validate every mandatory tile matrix set with multiple zoon levels in DGIWG GeoPackage to be compliant with all or a subset of the zoom levels for the corresponding CRS in Annex D of [6] OGC 17-083r2.

```
ATS produces a validation result of each row in gpkg_tile_matrix_set. If any
zoom level fails, the entire tile_matrix_set fails.

Case 1: gpkg_tile_matrix_set is consistent with [6] OGC 17-083r2. Verify all
consecutive zoom levels are adjacent.

For each tile matrix set _t_ in gpkg_contents where the
gpkg_contents.data_type of _t_ = "tiles",
  Set default Tile_Matrix_Set-multiple-zoom(_t_) to Pass.
  If <<ATS-ref_test09,ATS 3.2>> is Pass for _t_
  Then
    For each zoom_level _z_ in gpkg_tile_matrix, starting at z = 1
      If pkg_tile_matrix(_z_).zoom_level is not adjacent (difference of 1) to
zoom level gpkg_tile_matrix(_z_ - 1).zoom_level
      Then Set Tile_Matrix_Set-multiple-zoom(_t_) to Fail.
    End For
  Else

Case 2: not an OGC 2D TMS, this requirement is not applicable.

    Set Tile_Matrix_Set-multiple-zoom(_t_) to Null.
  End If
End For
```

Table A-7.3 ATS 7.3

Test identifier:	http://www.dgiwg.org/std/gpkg/1.0/conf/zoom/matrix-sets-one
Test purpose:	Verify that a DGIWG GeoPackage is conformant to the Matrix Sets GPKG (http://www.dgiwg.org/gpkg/1.0/conf/zoom/matrix-sets-one)
Requirements:	/req/zoom/matrix-sets-one
Conformance Class:	zoom
Test type:	Capability

Test method:	Validate every tile matrix set in DGIWG GeoPackage that does not have a set of zoom levels for the corresponding CRS in Annex D of [6] OGC 17-083r2 has only one zoom level to be compliant with http://www.dgiwg.org/std/gpkg/1.0/conf/zoom/matrix-sets-one.

```
ATS produces a validation result of each row in gpkg_tile_matrix_set if the
set only has 1 zoom level; else the test result is not applicable (NULL).

For each tile matrix set _t_ in gpkg_contents where the
gpkg_contents.data_type of _t_ = "tiles",
  Set default Tile_Matrix_Set-one-zoom(_t_) to Pass.
  If count of rows in gpkg_tile_matrix(_t_).zoom_level = 1
  Then
    If gpkg_tile_matrix(_t_).zoom_level != zoom_level in
gpkg_tile_matrix(_t_).table_name
    Then Set Tile_Matrix_Set-one-zoom(_t_) to Fail.
    Else
      Note - gpkg_tile_matrix(_t_) has > 1 zoom levels.
      Set Tile_Matrix_Set-one-zoom(_t_) to Null.
  End If
End For
```

A.8 Conformance Class Bounding Box (bbox)

Table A-8.1 ATS 8.1

Test identifier:	http://www.dgiwg.org/std/gpkg/1.0/conf/bbox/crs
Test purpose:	Verify that a DGIWG GeoPackage is conformant to the CRS BBOX GPKG (http://www.dgiwg.org/std/gpkg/1.0/conf/bbox/crs)
Requirements:	/req/bbox/crs
Conformance Class:	bbox
Test type:	Capability
Test method:	Validate every CRS bounding box in DGIWG GeoPackage to be compliant with http://www.dgiwg.org/std/gpkg/1.0/conf/bbox/crs.

```
ATS produces a validation result of each row in gpkg_tile_matrix_set - Pass
within CRS MBR, Fall outside CRS MBR or invalid CRS in tile matrix set.

// Note: _t_ is table_name in gpkg_contents and gpkg_tile_matrix_set
For each gpkg_tile matrix_set  _t_ in gpkg_contents where the
gpkg_contents.data_type of _t_ = "tiles",
  If ATSX.Y for _t_ is Pass (the crs/srs is valid)
  Then
    Where the srs_id of gpkg_tile_matrix_set for _t_ equals the corresponding
crs _c_ in gpkg_spatial_ref_sys.srs_id
    If the bounds of tile_matrix_set _t_ are within the bounds of crs _c_
within 1 meter
      Set Tile_Matrix_Set-bbox(_t_) to Pass.
      A within expression below can be used when it accounts for E/W lon x
and N/S lat y.
       gpkg_tile_matrix_set(_t_).min_x >= gpkg_spatial_ref_sys(_c_).min_x AND
       gpkg_tile_matrix_set(_t_).min_y >= gpkg_spatial_ref_sys(_c_).min_y AND
       gpkg_tile_matrix_set(_t_).max_x <= gpkg_spatial_ref_sys(_c_).max_x AND
       gpkg_tile_matrix_set(_t_).max_y <= gpkg_spatial_ref_sys(_c_).max_y
    Then
      Set Tile_Matrix_Set-bbox(_t_) to Fail
    End If
  Else (crs/srs__id is invalid in gpkg_tile_matrix_set)
    Set Tile_Matrix_Set-bbox(_t_) to Fail
  End If
End For
```

Annex B GeoPackage Metadata Reference

The relationships between DMF and NMF in Table-B-1 illustrate which DMF terms can be translated from one standard to another.

Table B-1: Mapping of DMF/Core to NMF Core metadata

DMF Identifier	DMF Title	NMF (v3.0) Core Metadata Concept
MDSID	Metadata Set Identifier	
MDPTMD (DMF/Common)	Parent Metadata Set (DMF/Common)	Parent Metadata Citation
MDDLOC	Metadata Default Locale	Metadata Language, Metadata Character Set
MDRPTY	Metadata Responsible Party	Metadata Point of Contact
MDDATE	Metadata Date Stamp	Metadata Date
MDSTD	Metadata Standard	Metadata Standard Title, Metadata Standard Edition
MDSCST (DMF/Common)	Metadata Security Constraint (DMF/Common)	Metadata Classification, Metadata Classification System
RSTITLE	Resource Title	Resource Title
RSABSTR	Resource Abstract	Resource Abstract
RSPURP	Resource Purpose	
RSTYPE	Resource Type Code	Metadata Scope Code
RSTYPN	Resource Type Name	Metadata Scope Name
RSED	Resource Edition	
RSEDDAT	Resource Edition Date	
RSID	Resource Identifier	Resource Identifier
RSKWDS	Resource Keyword Set	Resource Keywords
THUMB	Resource Thumbnail	
RSSRES	Resource Spatial Resolution	
RSRPTP	Resource Spatial Representation Type	
RSTOPIC	Resource Topic Category	Resource Topic Category Code

DMF Identifier	DMF Title	NMF (v3.0) Core Metadata Concept
RSDLOC	Resource Default Locale	Resource Language, Resource Character Set
RSTLOC	Resource Other Locale	
DGITYP	Geospatial Information Type	
RSGFLV	Resource Georeferencing Level	
RSPREF	Resource Representation Form	
RSTHEME	Resource Theme	
RSSERI	Name of Resource Series	
RSSHNA	Resource Sheet Name	
SRTYPE	Service Type	Service Type Name
SRTVER	Service Type Version	Service Type Version
SRSTD	Service Standard	
SRCPLING	Service Coupling Type	Coupled Resource Type
SROPRS	Resource Operated by the Service	
SROPER	Service Operation	Service Operation Name
SRCORS	Service Coupled Resource	Coupled Resource
RSEXT	Resource Extent	Resource Geographic Location, Resource Temporal Extent
RSRSYS	Resource Reference System	Resource Coordinate Reference System
RSDATE	Resource Reference Date	Resource Date
RSRPTY	Resource Responsible Party	Resource Point of Contact
RSSCST	Resource Security Constraint	Resource Classification, Resource Classification System
RSUSE	Resource Use Limitation	
RSLCST	Resource Legal Constraint	
RSLING	Resource Lineage	
RSDFMT	Resource Distribution Format	
RSONLLC	Resource Online Location	
		Resource Category (NMF Extension)

Table B-2 Example row in gpkg_metadata table for a GeoPackage DMF Metadata

id	md_scope	md_standard_uri	mime_type	metadata
1	dataset	DMF v2.0 https://dgiwg.org/std/dmf/2.0	text/xml	Complete DMF for entire GeoPackage (Figure B-1)

Table B-3 Example row in gpkg_metadata table for a GeoPackage NMIS / NMF Metadata

id	md_scope	md_standard_uri	mime_type	metadata
1	dataset	NMIS v3.0 https://nsgreg-api.nga.mil/schema/nas/8.0	text/xml	Complete NMIS for entire GeoPackage (Figure B-2)

Figure-B-1 provides an example XML instance documents for DMF 2.0.

Figure B-1 - DMF v2.0 - Example 1

```
<?xml version="1.0" encoding="UTF-8"?>
<!--.................................-->
<!-- DMF 2.0 sample for OSM vector Data in GeoPackage   -->
<!--       Encoding: ISO 19139                          -->
<!--         Date: 2019-10-2                            -->
<!--           Version : 1                              -->
<!--          Author: DGIWG                             -->
<!--.................................................. -->
<gmd:MD_Metadata xsi:schemaLocation="
urn:dgiwg:xmlns:dmf:2.0:iso-g1:profile:all www.dgiwg.org\xmlns\dmf\2.0\iso-
g1\profile\all\all.xsd" xmlns:all="http://www.dgiwg.org/xmlns/dmf/iso-
g1/all/1.0" xmlns:xs="http://www.w3.org/2001/XMLSchema" xmlns:xlink=
"http://www.w3.org/1999/xlink" xmlns:gco="http://www.isotc211.org/2005/gco"
xmlns:egco=" http://www.dgiwg.org/xmlns/dmf/iso-g1/egco/1.0" xmlns:gsr=
"http://www.isotc211.org/2005/gsr" xmlns:gss=
"http://www.isotc211.org/2005/gss" xmlns:gts=
"http://www.isotc211.org/2005/gts" xmlns:gmd=
"http://www.isotc211.org/2005/gmd" xmlns:gmx=
"http://www.isotc211.org/2005/gmx" xmlns:srv=
"http://www.isotc211.org/2005/srv" xmlns:gmi=
"http://www.isotc211.org/2005/gmi" xmlns:ngmp=
"urn:int:nato:geometoc:geo:metadata:ngmp:1.0" xmlns:xsi=
"http://www.w3.org/2001/XMLSchema-instance" xmlns:gml=
```

```
"http://www.opengis.net/gml/3.2" xmlns:sensor=
"http://www.opengis.net/spec/spec/sensorml/2.0/req/core">

        <!-- MDDLOC.language [1] -->
        <gmd:language>
            <gmd:LanguageCode codeList=
"http://www.isotc211.org/2005/resources/Codelist/ML_gmxCodelists.xml#Language
Code" codeListValue="eng">eng</gmd:LanguageCode>
        </gmd:language>
        <!-- MDDLOC.encoding [1] -->
        <gmd:characterSet>
            <gmd:MD_CharacterSetCode codeList=
"http://www.isotc211.org/2005/resources/Codelist/gmxCodelists.xml#MD_Characte
rSetCode" codeListValue="utf8">utf8</gmd:MD_CharacterSetCode>
        </gmd:characterSet>

    <!-- MDRPTY [1..*] -->
    <gmd:contact>
        <!-- MDRPTY.party [1] -->
        <gmd:CI_ResponsibleParty>
            <!-- MDRPTY.party.orgName [0..1] -->
            <gmd:organisationName>
                <gco:CharacterString>DGIWG</gco:CharacterString>
            </gmd:organisationName>
            <gmd:contactInfo>
                <gmd:CI_Contact>
                    <gmd:phone>
                        <gmd:CI_Telephone>
                            <!-- MDRPTY.party.phone [0..*] -->
                            <gmd:voice>
                                <gco:CharacterString>001 571-557-
5450</gco:CharacterString>
                            </gmd:voice>
                        </gmd:CI_Telephone>
                    </gmd:phone>
                    <gmd:address>
                    <!-- MDRPTY.party.address [0..*] -->
                        <gmd:CI_Address>
                            <gmd:deliveryPoint>
                                <gco:CharacterString>NGA Visitor Center, 7500
GEOINT Dr, Springfield, VA 22150</gco:CharacterString>
                            </gmd:deliveryPoint>
                            <!-- MDRPTY.party.city [0..1] -->
                            <gmd:city>
                                <gco:CharacterString>
```

```
Springfield</gco:CharacterString>
                            </gmd:city>
                            <!-- MDRPTY.party.postalCode [0..1] -->
                            <gmd:postalCode>
                                <gco:CharacterString>
22150</gco:CharacterString>
                            </gmd:postalCode>
                            <!-- MDRPTY.party.country [0..1] -->
                            <gmd:country>
                                <gco:CharacterString>United States
(USA)</gco:CharacterString>
                            </gmd:country>
                            <!-- MDRPTY.party.email [0..*] -->
                            <!-- <gmd:electronicMailAddress> -->
                                <!--
<gco:CharacterString>christopherstow594@mod.gov.uk</gco:CharacterString> -->
                            <!-- </gmd:electronicMailAddress> -->
                        </gmd:CI_Address>
                    </gmd:address>
                </gmd:CI_Contact>
            </gmd:contactInfo>
            <!-- MDRPTY.role [1] -->
            <gmd:role>
                <gmd:CI_RoleCode codeList=
"http://api.nsgreg.nga.mil/codelist/RoleCode" codeListValue="originator"
>Originator</gmd:CI_RoleCode>
            </gmd:role>
        </gmd:CI_ResponsibleParty>
    </gmd:contact>

        <!-- MDDATE [1] -->
        <gmd:dateStamp>
            <gco:Date>20201201T12:58:03Z</gco:Date>
        </gmd:dateStamp>

        <!-- MDSTD [1] -->
        <!-- MDSTD.title [1] -->
        <gmd:metadataStandardName>
            <gmx:Anchor>urn:dgiwg:metadata:dmf:2.0:profile:all</gmx:Anchor>
        </gmd:metadataStandardName>
        <!-- MDSTD.version [1] -->
        <gmd:metadataStandardVersion>
            <gco:CharacterString>2.0</gco:CharacterString>
        </gmd:metadataStandardVersion>
```

```
        <!-- RSTITLE [1] -->
        <gmd:title>
            <gco:CharacterString>Puerto Rico Sample</gco:CharacterString>
        </gmd:title>

        <!-- RSABSTR [1] -->
        <gmd:abstract>
            <gco:CharacterString>OSM Vector Dataset created composed of
waterbodies, roads and points of interest (POI) from OSM data downloaded from
Geofabrik.</gco:CharacterString>
        </gmd:abstract>

        <!-- RSPURP [1] -->
        <gmd:purpose>
        <gco:CharacterString>The purpose of this dataset is to provide a
sample dataset for GeoPackage development and use.</gco:CharacterString>
        </gmd:purpose>

        <!-- RSED [0..1] -->
        <gmd:edition>
            <gco:CharacterString>OSM</gco:CharacterString>
        </gmd:edition>

        <!-- RSEDDAT [0..1] -->
        <gmd:editionDate>
            <gco:Date>20201201</gco:Date>
        </gmd:editionDate>

        <!-- RSID [0..*] -->
        <gmd:identifier>
            <gmd:RS_Identifier>
                <!-- RSID.code [1] -->
                <gmd:code>
                    <gco:CharacterString>Geofabrik OSM</gco:CharacterString>
                </gmd:code>
            </gmd:RS_Identifier>
        </gmd:identifier>

        <!-- RSSRES [0..*] -->
        <gmd:spatialResolution>
            <gmd:MD_Resolution>
            <!-- RSSRES.equivalentScale [0..1] -->
                <gmd:equivalentScale>
                    <gmd:MD_RepresentativeFraction>
                        <gmd:denominator>
```

```
                            <gco:Integer>25000</gco:Integer>
                        </gmd:denominator>
                    </gmd:MD_RepresentativeFraction>
                </gmd:equivalentScale>
                <!--RSSRES.distance [0..1] not set -->
            </gmd:MD_Resolution>
        </gmd:spatialResolution>

        <!-- RSRPTP [0..1] -->
        <gmd:spatialRepresentationType>
            <gmd:MD_SpatialRepresentationTypeCode codeList=
"http://standards.iso.org/iso/19115/resources/Codelists/cat/codelists.xml#CI_
RoleCode" codeListValue="vector">
Vector</gmd:MD_SpatialRepresentationTypeCode>
        </gmd:spatialRepresentationType>

        <!-- RSDLOC [1] -->
        <!-- RSDLOC.language [1] -->
        <gmd:language>
            <gmd:LanguageCode codeList=
"http://www.isotc211.org/2005/resources/Codelist/ML_gmxCodelists.xml#Language
Code" codeListValue="eng">eng</gmd:LanguageCode>
        </gmd:language>
        <!-- RSDLOC.encoding [1] -->
        <gmd:characterSet>
            <gmd:MD_CharacterSetCode codeList=
"http://www.isotc211.org/2005/resources/Codelist/gmxCodelists.xml#MD_Characte
rSetCode" codeListValue="utf8">utf8</gmd:MD_CharacterSetCode>
        </gmd:characterSet>

        <!-- DGITYP.keyword [1..*] -->
        <gmd:descriptiveKeywords>
            <gmd:MD_Keywords>
            <!-- DGITYP.keyword [1..*] -->
                <gmd:keyword>
                    <ngmp:NGMP_GeospatialInformationTypeCode codeList=
"http://www.dgiwg.org/resources/Codelist/dgiwgCodelists.xml#MD_GeospatialInfo
rmationTypeCode" codeListValue="vector2D">Vector
2D</ngmp:NGMP_GeospatialInformationTypeCode>
                </gmd:keyword>
                <!-- DGITYP.thesaurus [0..1] -->
                <gmd:thesaurusName>
                    <gmd:CI_Citation>
                        <!-- DGITYP.thesaurus.title [1] -->
                        <gmd:title>
```

```
<gco:CharacterString>NGMP_GeospatialInformationTypeCode</gco:CharacterString>
                        </gmd:title>
                        <!-- DGITYP.thesaurus.referenceDate [0..*] -->
                        <gmd:date>
                            <gmd:CI_Date>
                        <!-- DGITYP.thesaurus.referenceDate.date [1] -->
                                <gmd:date>
                                    <gco:Date>20110916</gco:Date>
                                </gmd:date>
                                <!-- DGITYP.thesaurus.referenceDate.type [1]
-->
                                <gmd:dateType>
                                    <gmd:CI_DateTypeCode codeList=
"http://standards.iso.org/iso/19115/resources/Codelists/cat/codelists.xml#CI_
DateTypeCode" codeListValue="creation">Creation</gmd:CI_DateTypeCode>
                                </gmd:dateType>
                            </gmd:CI_Date>
                        </gmd:date>
                    </gmd:CI_Citation>
                </gmd:thesaurusName>
            </gmd:MD_Keywords>
        </gmd:descriptiveKeywords>

        <!-- RSGFLV [0..1] -->
        <gmd:descriptiveKeywords>
            <gmd:MD_Keywords>
            <!-- RSGFLV.keyword [1..*] -->
                <gmd:keyword>
                    <ngmp:NGMP_GeoreferencingLevelCode codeList=
"http://www.dgiwg.org/resources/Codelist/dgiwgCodelists.xml#MD_Geopositioning
LevelCode" codeListValue="georectified">
georectified</ngmp:NGMP_GeoreferencingLevelCode>
                </gmd:keyword>
                <!-- RSGFLV.thesaurus [0..1] -->
                <gmd:thesaurusName>
                    <gmd:CI_Citation>
                        <!-- RSGFLV.thesaurus.title [1] -->
                        <gmd:title>
                            <gco:CharacterString>
NGMP_GeoreferencingLevelCode</gco:CharacterString>
                        </gmd:title>
                        <!-- RSGFLV.thesaurus.referenceDate [0..*] -->
                        <gmd:date>
                            <gmd:CI_Date>
```

```
                                <!-- RSGFLV.thesaurus.referenceDate.date [1]
-->
                                <gmd:date>
                                    <gco:Date>20190125</gco:Date>
                                </gmd:date>
                                <!-- RSGFLV.thesaurus.referenceDate.type [1]
-->
                                <gmd:dateType>
                                    <gmd:CI_DateTypeCode codeList=
"http://standards.iso.org/iso/19115/resources/Codelists/cat/codelists.xml#CI_
DateTypeCode" codeListValue="creation">Creation</gmd:CI_DateTypeCode>
                                </gmd:dateType>
                            </gmd:CI_Date>
                        </gmd:date>
                    </gmd:CI_Citation>
                </gmd:thesaurusName>
            </gmd:MD_Keywords>
        </gmd:descriptiveKeywords>

        <!-- RSTHEME [0..1] -->
        <gmd:descriptiveKeywords>
            <gmd:MD_Keywords>
                <!-- RSTHEME.keyword [1..*] -->
                <gmd:keyword>
                    <ngmp:NGMP_ThematicCode codeList=
"http://www.dgiwg.org/resources/Codelist/dgiwgCodelists.xml#RS_ThematicCode"
codeListValue="extraction">Extraction</ngmp:NGMP_ThematicCode>
                </gmd:keyword>
                <gmd:keyword>
                    <ngmp:NGMP_ThematicCode codeList=
"http://www.dgiwg.org/resources/Codelist/dgiwgCodelists.xml#RS_ThematicCode"
codeListValue="associatedSupportStruct">Associated Support
Structures</ngmp:NGMP_ThematicCode>
                </gmd:keyword>
                <!-- RSTHEME.thesaurus [0..1] -->
                <gmd:thesaurusName>
                    <gmd:CI_Citation>
                        <!-- RSTHEME.thesaurus.title [1] -->
                        <gmd:title>
                            <gco:CharacterString>
NGMP_ThematicCode</gco:CharacterString>
                        </gmd:title>
                        <!-- RSTHEME.thesaurus.referenceDate [0..*] -->
                        <gmd:date>
                            <gmd:CI_Date>
```

```
                                <!-- RSTHEME.thesaurus.referenceDate.date [1]
-->
                                <gmd:date>
                                    <gco:Date>20190125</gco:Date>
                                </gmd:date>
                                <!-- RSTHEME.thesaurus.referenceDate.type [1]
-->
                                <gmd:dateType>
                                    <gmd:CI_DateTypeCode codeList=
"http://standards.iso.org/iso/19115/resources/Codelists/cat/codelists.xml#CI_
DateTypeCode" codeListValue="creation">Creation</gmd:CI_DateTypeCode>
                                </gmd:dateType>
                            </gmd:CI_Date>
                        </gmd:date>
                    </gmd:CI_Citation>
                </gmd:thesaurusName>
            </gmd:MD_Keywords>
        </gmd:descriptiveKeywords>

        <!-- RSEXT [0..*] -->
        <gmd:extent>
            <gmd:EX_Extent>
                <gmd:geographicElement>
                    <!-- RSEXT.boundingBox [0..*] -->
                    <gmd:EX_GeographicBoundingBox>
                        <!-- RSEXT.boundingBox.west [1] -->
                        <gmd:westBoundLongitude>
                            <gco:Decimal>-67.010729</gco:Decimal>
                        </gmd:westBoundLongitude>
                        <!-- RSEXT.boundingBox.east [1] -->
                        <gmd:eastBoundLongitude>
                            <gco:Decimal>-66.408509</gco:Decimal>
                        </gmd:eastBoundLongitude>
                        <!-- RSEXT.boundingBox.south [1] -->
                        <gmd:southBoundLatitude>
                            <gco:Decimal>18.408509</gco:Decimal>
                        </gmd:southBoundLatitude>
                        <!-- RSEXT.boundingBox.north [1] -->
                        <gmd:northBoundLatitude>
                            <gco:Decimal>18.500550</gco:Decimal>
                        </gmd:northBoundLatitude>
                    </gmd:EX_GeographicBoundingBox>
                </gmd:geographicElement>
            </gmd:EX_Extent>
        </gmd:extent>
```

```
        <!-- RSRSYS (horizontal) [0..*] -->
        <gmd:MD_ReferenceSystem>
            <gmd:referenceSystemIdentifier>
                <gmd:RS_Identifier>
                <!-- RSRSYS.code [1] -->
                    <gmd:code>

<gco:CharacterString>http://www.opengis.net/def/crs/EPSG/0/4326</gco:Characte
rString>
                    </gmd:code>
                    <!-- RSRSYS.namespace [0..1] -->
                    <gmd:codeSpace>
                        <gco:CharacterString>
//www.opengis.net/def/crs/EPSG</gco:CharacterString>
                    </gmd:codeSpace>
                    <!-- RSRSYS.description [0..1] not set -->
                </gmd:RS_Identifier>
            </gmd:referenceSystemIdentifier>
        </gmd:MD_ReferenceSystem>

            <!-- DMF/Core -->
            <!-- RSRSYS (vertical) [0..*] -->
        <gmd:referenceSystemInfo>
            <gmd:MD_ReferenceSystem>
                <gmd:referenceSystemIdentifier>
                    <gmd:RS_Identifier>
                    <!-- RSRSYS.code [1] -->
                        <gmd:code>
                            <gmx:Anchor xlink:href=
"http://www.opengis.net/def/crs/EPSG/0/5773">EGM96</gmx:Anchor>
                        </gmd:code>
                        <!-- RSRSYS.namespace [0..1] not set -->
                        <!-- RSRSYS.description [0..1] not set -->
                    </gmd:RS_Identifier>
                </gmd:referenceSystemIdentifier>
            </gmd:MD_ReferenceSystem>
        </gmd:referenceSystemInfo>

        <!-- DMF/Core -->
        <!-- RSDATE [1..*] -->
        <gmd:date>
            <gmd:CI_Date>
                <!-- RSDATE.date [1] -->
                <gmd:date>
```

```
                    <gco:Date>20201201</gco:Date>
                </gmd:date>
                <!-- RSDATE.type [1] -->
                <gmd:dateType>
                    <gmd:CI_DateTypeCode codeList=
"http://standards.iso.org/iso/19115/resources/Codelists/cat/codelists.xml#CI_
DateTypeCode" codeListValue="creation">Creation</gmd:CI_DateTypeCode>
                </gmd:dateType>
            </gmd:CI_Date>
        </gmd:date>

        <!-- DMF/Core -->
        <!-- RSRPTY [0..*] -->
        <gmd:pointOfContact>
        <!-- RSRPTY.party [1] -->
            <gmd:CI_ResponsibleParty>
                <!-- RSRPTY.party.orgName [0..1] -->
                <gmd:organisationName>
                    <gco:CharacterString>"DGIWG"</gco:CharacterString>
                </gmd:organisationName>
                <gmd:contactInfo>
                    <gmd:CI_Contact>
                        <gmd:phone>
                            <gmd:CI_Telephone>
                                <!-- RSRPTY.party.phone [0..*] -->
                                <gmd:voice>
                                    <gco:CharacterString>See web site for
contact details</gco:CharacterString>
                                </gmd:voice>
                            </gmd:CI_Telephone>
                        </gmd:phone>
                    </gmd:CI_Contact>
                </gmd:contactInfo>
                <!-- RSRPTY.role [1] -->
                <gmd:role>
                    <gmd:CI_RoleCode codeList=
"http://standards.iso.org/iso/19115/resources/Codelists/cat/codelists.xml#CI_
RoleCode" codeListValue="originator">Originator</gmd:CI_RoleCode>
                </gmd:role>
            </gmd:CI_ResponsibleParty>
        </gmd:pointOfContact>

        <!-- RSSCST [0..*] -->
        <gmd:resourceConstraints>
            <gmd:MD_SecurityConstraints>
```

```
                <!-- RSSCST.level [1] -->
                <gmd:classification>
                    <gmd:MD_ClassificationCode codeList=
"http://www.isotc211.org/2005/resources/Codelist/gmxCodelists.xml#MD_Classifi
cationCode" codeListValue="unclassified">
Unclassified</gmd:MD_ClassificationCode>
                </gmd:classification>
                <!-- RSSCST.system [0..1] -->
                <gmd:classificationSystem>
                    <gco:CharacterString>USA</gco:CharacterString>
                </gmd:classificationSystem>
            </gmd:MD_SecurityConstraints>
        </gmd:resourceConstraints>
        <gmd:resourceConstraints>

        <!-- DMF/Core -->
        <!-- RSUSE [0..*] -->
            <gmd:MD_Constraints>
                <gmd:useLimitation>
                    <gco:CharacterString>For evaluation
only</gco:CharacterString>
                </gmd:useLimitation>
            </gmd:MD_Constraints>
        </gmd:resourceConstraints>

        <!-- RSLCST [0..*] -->
        <gmd:resourceConstraints>
            <gmd:MD_LegalConstraints>
            <!-- RSLCST.statement [0..*] not set -->
                <!-- RSLCST.access [0..*] -->
                <gmd:accessConstraints>
                    <gmd:MD_RestrictionCode codeList=
"http://standards.iso.org/iso/19115/resources/Codelists/cat/codelists.xml#MD_
RestrictionCode" codeListValue="restricted"/>
                </gmd:accessConstraints>
                <!-- RSLCST.use [0..*] -->
                <gmd:useConstraints>
                    <gmd:MD_RestrictionCode codeList=
"http://standards.iso.org/iso/19115/resources/Codelists/cat/codelists.xml#MD_
RestrictionCode" codeListValue="copyright"/>
                </gmd:useConstraints>
                <!-- RSLCST.other [0..*] -->
                <gmd:otherConstraints>
                    <gco:CharacterString>DGIWG use only</gco:CharacterString>
                </gmd:otherConstraints>
```

```
            </gmd:MD_LegalConstraints>
        </gmd:resourceConstraints>

        <!-- RSLING [1] -->
            <gmd:lineage>
                <gmd:LI_Lineage>
                    <gmd:statement>
                        <gco:CharacterString>Features created by Open Street
Map open source community using various imagery sources and collection
methods.</gco:CharacterString>
                    </gmd:statement>
                    <gmd:processStep>
                        <gmd:LI_ProcessStep>
                        <!-- DMF/Common -->
                            <!-- RSPRST [0..*] -->
                            <!-- RSPRST.description [1] -->
                            <gmd:description>
                                <gco:CharacterString>Download and generate
data vector datasets in GeoPackage format</gco:CharacterString>
                            </gmd:description>
                            <!-- RSPRST.rationale [0..1] -->
                            <gmd:rationale>
                                <gco:CharacterString>Time
constraints</gco:CharacterString>
                            </gmd:rationale>
                            <!-- RSPRST.date [0..1] -->
                            <gmd:dateTime>
                                <gco:DateTime>2019-01-
25T12:58:03Z</gco:DateTime>
                            </gmd:dateTime>
                            <!-- RSPRST.processor [0..*] -->
                            <gmd:processor>
                            <!-- RSPRST.processor.party [1] -->
                                <gmd:CI_ResponsibleParty>
                                    <!-- RSPRST.processor.party.orgName
[0..1] -->
                                    <gmd:organisationName>
                                        <gco:CharacterString>
"USA"</gco:CharacterString>
                                    </gmd:organisationName>
                                    <!-- RSPRST.processor.party.phone [0..*]
-->
                                    <gmd:contactInfo>
                                        <gmd:CI_Contact>
                                            <gmd:phone>
```

```
                                                    <gmd:CI_Telephone>
                                                        <gmd:voice>

<gco:CharacterString>+001 571-557-5450</gco:CharacterString>
                                                        </gmd:voice>
                                                    </gmd:CI_Telephone>
                                                </gmd:phone>
                                            </gmd:CI_Contact>
                                        </gmd:contactInfo>
                                        <!-- RSPRST.processor.role [1] -->
                                        <gmd:role>
                                            <gmd:CI_RoleCode codeList=
"http://standards.iso.org/iso/19115/resources/Codelists/cat/codelists.xml#CI_
RoleCode" codeListValue="processor">Processor</gmd:CI_RoleCode>
                                        </gmd:role>
                                    </gmd:CI_ResponsibleParty>
                                </gmd:processor>
                            </gmd:LI_ProcessStep>
                        </gmd:processStep>
                    </gmd:LI_Lineage>
                </gmd:lineage>

            <!-- RSDFMT [1..*] -->
            <gmd:distributionInfo>
                <gmd:MD_Distribution>
                    <gmd:distributionFormat>
                    <!-- RSDFMT.citation.title [1] -->
                        <gmd:MD_Format>
                            <gmd:name>
                                <gco:CharacterString>
GeoPackage</gco:CharacterString>
                            </gmd:name>
                            <!-- RSDFMT.citation.version [0..1] -->
                            <gmd:version>
                                <gco:CharacterString>OGC</gco:CharacterString>
                            </gmd:version>
                            <!-- RSDFMT.decompression [0..1] -->
                            <gmd:fileDecompressionTechnique>
                                <gco:CharacterString>zip</gco:CharacterString>
                            </gmd:fileDecompressionTechnique>
                        </gmd:MD_Format>
                    </gmd:distributionFormat>
                </gmd:MD_Distribution>
            </gmd:distributionInfo>
```

```
        <!-- RSONLLC [0..*] -->
        <gmd:transferOptions>
            <gmd:MD_DigitalTransferOptions>
                <gmd:onLine>
                    <gmd:CI_OnlineResource>
                        <!-- RSONLLC.location [1] -->
                        <gmd:linkage>

<gmd:URL>https://www.arcgis.com/apps/webappviewer/index.html?id=10fc70d81a974
52fa232336637d69313</gmd:URL>
                        </gmd:linkage>
                        <!-- RSONLLC.function [0..1] -->
                        <gmd:function>
                            <gmd:CI_OnLineFunctionCode codeList=
"http://www.isotc211.org/2005/resources/Codelist/gmxCodelists.xml#CI_OnLineFu
nctionCode" codeListValue="download">Download</gmd:CI_OnLineFunctionCode>
                        </gmd:function>
                    </gmd:CI_OnlineResource>
                </gmd:onLine>
            </gmd:MD_DigitalTransferOptions>
        </gmd:transferOptions>
</gmd:MD_Metadata>
```

Figure-B-2 provides an example XML instance documents for NMIS / NMF 3.0

Figure B-2 - NMIS / NMF v3.0 - Example 1

```
<?xml version="1.0" encoding="UTF-8"?>
<!--
**********************************************************************
**************************************************
* This is an example XML document that conforms to the NSG Application Schema
(NAS) under
* NSG Metadata Foundation (NMF) 3.0 Identification and Access Profile of the
NAS.  This example includes IC-ISM
* security markings and defines Resource Geographic Location by geographic
description with a temporal extent
* expressed as a period.
**********************************************************************
**************************************************-->
<nas:MD_Metadata xmlns:nas="https://nsgreg-api.nga.mil/schema/nas/8.0"
xmlns:cit="http://standards.iso.org/iso/19115/-3/cit/1.0"
xmlns:gco="http://standards.iso.org/iso/19115/-3/gco/1.0"
xmlns:gex="http://standards.iso.org/iso/19115/-3/gex/1.0"
```

```
xmlns:lan="http://standards.iso.org/iso/19115/-3/lan/1.0"
xmlns:mcc="http://standards.iso.org/iso/19115/-3/mcc/1.0"
xmlns:mco="http://standards.iso.org/iso/19115/-3/mco/1.0"
xmlns:mdb="http://standards.iso.org/iso/19115/-3/mdb/1.0"
xmlns:mri="http://standards.iso.org/iso/19115/-3/mri/1.0"
xmlns:mrs="http://standards.iso.org/iso/19115/-3/mrs/1.0"
xmlns:gml="http://www.opengis.net/gml/3.2"
xmlns:xlink="http://www.w3.org/1999/xlink"
xmlns:ism="urn:us:gov:ic:ism"
xmlns:ntk="urn:us:gov:ic:ntk"
xmlns:rr="urn:us:gov:ic:revrecall"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="https://nsgreg-api.nga.mil/schema/nas/8.0 ./nmis.xsd"
ism:DESVersion="13"
ism:ISMCATCESVersion="2"
ntk:DESVersion="10"
rr:DESVersion="1"
ism:resourceElement="true" ism:createDate="2016-05-30" ism:classification="U"
ism:ownerProducer="USA" ism:compliesWith="USGov">
    <mdb:defaultLocale>
        <lan:PT_Locale>
            <lan:language>
                <lan:LanguageCode codeList="https://nsgreg-
api.nga.mil/codelist/iso639-2" codeListValue="eng"/>
            </lan:language>
            <lan:country>
                <lan:CountryCode codeList="http://api.nsgreg.nga.mil/N2L?"
codeListValue="ge:GENC:3:3-3:USA"/>
            </lan:country>
            <lan:characterEncoding>
                <lan:MD_CharacterSetCode codeList="https://nsgreg-
api.nga.mil/codelist/IANACharset" codeListValue="UTF-8"/>
            </lan:characterEncoding>
        </lan:PT_Locale>
    </mdb:defaultLocale>
    <mdb:parentMetadata>
        <cit:CI_Citation>
            <cit:title>
                <gco:CharacterString>LTDS_39N078W_A-P</gco:CharacterString>
            </cit:title>
        </cit:CI_Citation>
    </mdb:parentMetadata>
    <mdb:metadataScope>
        <mdb:MD_MetadataScope>
            <mdb:resourceScope>
```

```
                <mcc:MD_ScopeCode codeList="https://nsgreg-
api.nga.mil/codelist/ScopeCode" codeListValue="dataset"/>
            </mdb:resourceScope>
            <mdb:name>
                <gco:CharacterString>cell</gco:CharacterString>
            </mdb:name>
        </mdb:MD_MetadataScope>
    </mdb:metadataScope>
    <mdb:contact xlink:href="#NgaOrganization"/>
    <mdb:dateInfo>
        <cit:CI_Date>
            <cit:date>
                <gco:DateTime>2016-05-30T09:30:47Z</gco:DateTime>
            </cit:date>
            <cit:dateType>
                <cit:CI_DateTypeCode codeList="https://nsgreg-
apih.nga.mil/codelist/DateTypeCode" codeListValue="creation"/>
            </cit:dateType>
        </cit:CI_Date>
    </mdb:dateInfo>
    <mdb:metadataStandard>
        <cit:CI_Citation>
            <cit:title>
                <gco:CharacterString>National System for Geospatial
Intelligence (NSG) Application Schema (NAS)</gco:CharacterString>
            </cit:title>
            <cit:alternateTitle>
                <gco:CharacterString>NAS</gco:CharacterString>
            </cit:alternateTitle>
            <cit:edition>
                <gco:CharacterString>8.0</gco:CharacterString>
            </cit:edition>
        </cit:CI_Citation>
    </mdb:metadataStandard>
    <mdb:identificationInfo>
        <nas:DataIdentification>
            <mri:citation>
                <cit:CI_Citation>
                    <cit:title>
                        <gco:CharacterString>Local Topographic Data Store
(LTDS) data sample for cell 39N078WA.</gco:CharacterString>
                    </cit:title>
                    <cit:date>
                        <cit:CI_Date>
                            <cit:date>
```

```
                                <gco:DateTime>2016-05-
30T09:30:47Z</gco:DateTime>
                            </cit:date>
                            <cit:dateType>
                                <cit:CI_DateTypeCode codeList=
"https://nsgreg-api.nga.mil/codelist/DateTypeCode" codeListValue=
"distribution"/>
                            </cit:dateType>
                        </cit:CI_Date>
                    </cit:date>
                    <cit:identifier>
                        <mcc:MD_Identifier>
                            <mcc:authority>
                                <cit:CI_Citation>
                                    <cit:title>
                                        <gco:CharacterString>NGA/S2
Topographic Feature Data Management (TFDM) system.</gco:CharacterString>
                                    </cit:title>
                                    <cit:date>
                                        <cit:CI_Date>
                                            <cit:date>
                                                <gco:DateTime>2016-04-
15T09:30:47Z</gco:DateTime>
                                            </cit:date>
                                            <cit:dateType>
                                                <cit:CI_DateTypeCode
codeList="https://nsgreg-api.nga.mil/codelist/DateTypeCode" codeListValue=
"creation"/>
                                            </cit:dateType>
                                        </cit:CI_Date>
                                    </cit:date>
                                </cit:CI_Citation>
                            </mcc:authority>
                            <mcc:code>
                                <gco:CharacterString>urn:uuid:65ab5357-d6cf-
4b25-a73a-8d76ed6aj367</gco:CharacterString>
                            </mcc:code>
                        </mcc:MD_Identifier>
                    </cit:identifier>
                    <cit:series>
                        <cit:CI_Series>
                            <cit:name>
                                <gco:CharacterString>Local Topographic Data
Store (LTDS) data samples for cell 39N078W.</gco:CharacterString>
                            </cit:name>
```

```
                        </cit:CI_Series>
                    </cit:series>
                </cit:CI_Citation>
            </mri:citation>
            <mri:abstract>
                <gco:CharacterString>A small-footprint sample of NAS-
conformant data located in the southern region of New Jersey, USA. It
contains a variety of urban, terrain, shoreline, and littoral vector-based
feature data, some of which are vertical obstructions to
aircraft.</gco:CharacterString>
            </mri:abstract>
            <mri:pointOfContact>
                <cit:CI_Responsibility>
                    <cit:role>
                        <cit:CI_RoleCode codeList="https://nsgreg-
api.nga.mil/codelist/RoleCode" codeListValue="originator"/>
                    </cit:role>
                    <cit:party>
                        <cit:CI_Organisation>
                            <cit:name>
                                <gco:CharacterString>US National Geospatial-
Intelligence Agency</gco:CharacterString>
                            </cit:name>
                        </cit:CI_Organisation>
                    </cit:party>
                </cit:CI_Responsibility>
            </mri:pointOfContact>
            <mri:topicCategory>
                <mri:MD_TopicCategoryCode>
boundaries</mri:MD_TopicCategoryCode>
            </mri:topicCategory>
            <mri:topicCategory>
                <mri:MD_TopicCategoryCode>
intelligenceMilitary</mri:MD_TopicCategoryCode>
            </mri:topicCategory>
            <mri:topicCategory>
                <mri:MD_TopicCategoryCode>
inlandWaters</mri:MD_TopicCategoryCode>
            </mri:topicCategory>
            <mri:topicCategory>
                <mri:MD_TopicCategoryCode>location</mri:MD_TopicCategoryCode>
            </mri:topicCategory>
            <mri:topicCategory>
                <mri:MD_TopicCategoryCode>oceans</mri:MD_TopicCategoryCode>
            </mri:topicCategory>
```

```
            <mri:topicCategory>
                <mri:MD_TopicCategoryCode>
structure</mri:MD_TopicCategoryCode>
            </mri:topicCategory>
            <mri:topicCategory>
                <mri:MD_TopicCategoryCode>
transportation</mri:MD_TopicCategoryCode>
            </mri:topicCategory>
            <mri:topicCategory>
                <mri:MD_TopicCategoryCode>
utilitiesCommunication</mri:MD_TopicCategoryCode>
            </mri:topicCategory>
            <mri:extent>
                <gex:EX_Extent>
                    <gex:geographicElement>
                        <gex:EX_GeographicDescription>
                            <gex:geographicIdentifier>
                                <mcc:MD_Identifier>
                                    <mcc:authority xlink:href=
"#NewJerseyGazetteer"/>
                                    <mcc:code>
                                        <gco:CharacterString>Southern New
Jersey</gco:CharacterString>
                                    </mcc:code>
                                </mcc:MD_Identifier>
                            </gex:geographicIdentifier>
                        </gex:EX_GeographicDescription>
                    </gex:geographicElement>
                    <gex:temporalElement>
                        <gex:EX_TemporalExtent>
                            <gex:extent>
                                <gml:TimePeriod gml:id=
"ResourceTemporalExtent">
                                    <gml:begin>
                                        <gml:TimeInstant gml:id=
"ResourceTemporalExtentBegin">
                                            <gml:timePosition
indeterminatePosition="unknown"/>
                                        </gml:TimeInstant>
                                    </gml:begin>
                                    <gml:end>
                                        <gml:TimeInstant gml:id=
"ResourceTemporalExtentEnd">
                                            <gml:timePosition>2010-01-
01</gml:timePosition>
```

```
                                        </gml:TimeInstant>
                                    </gml:end>
                                </gml:TimePeriod>
                            </gex:extent>
                        </gex:EX_TemporalExtent>
                    </gex:temporalElement>
                </gex:EX_Extent>
            </mri:extent>
            <mri:descriptiveKeywords>
                <mri:MD_Keywords>
                    <mri:keyword>
                        <gco:CharacterString>Boundaries and
Lines</gco:CharacterString>
                    </mri:keyword>
                    <mri:keyword>
                        <gco:CharacterString>General
Structures</gco:CharacterString>
                    </mri:keyword>
                </mri:MD_Keywords>
            </mri:descriptiveKeywords>
            <mri:descriptiveKeywords>
                <mri:MD_Keywords>
                    <mri:keyword>
                        <gco:CharacterString>Woeful Weeping
Willow</gco:CharacterString>
                    </mri:keyword>
                    <mri:keyword>
                        <gco:CharacterString>Conspicuously Cheerful
Charthouse</gco:CharacterString>
                    </mri:keyword>
                </mri:MD_Keywords>
            </mri:descriptiveKeywords>
            <mri:resourceConstraints>
                <mco:MD_SecurityConstraints>
                    <mco:classification>
                        <mco:MD_ClassificationCode codeList="https://nsgreg-
api.nga.mil/codelist/ClassificationCode" codeListValue="unclassified"/>
                    </mco:classification>
                    <mco:classificationSystem>
                        <gco:CharacterString>USA</gco:CharacterString>
                    </mco:classificationSystem>
                </mco:MD_SecurityConstraints>
            </mri:resourceConstraints>
            <mri:defaultLocale>
                <lan:PT_Locale>
```

```
                    <lan:language>
                        <lan:LanguageCode codeList="https://nsgreg-
api.nga.mil/codelist/ISO639-2" codeListValue="eng"/>
                    </lan:language>
                    <lan:country>
                        <lan:CountryCode codeList=
"http://api.nsgreg.nga.mil/N2L?" codeListValue="ge:GENC:3:3-3:USA"/>
                    </lan:country>
                    <lan:characterEncoding>
                        <lan:MD_CharacterSetCode codeList="https://nsgreg-
api.nga.mil/codelist/IANACharset" codeListValue="UTF-8"/>
                    </lan:characterEncoding>
                </lan:PT_Locale>
            </mri:defaultLocale>
            <nas:resourceCategory codeSpace="https://nsgreg-
api.nga.mil/codelist/ResourceCategoryCode">topographicFeatures</nas:resourceC
ategory>
        </nas:DataIdentification>
    </mdb:identificationInfo>
</nas:MD_Metadata>
```

Annex C GeoPackage to EPSG Registry Crosswalk

This Annex provides a crosswalk between the Coordinate Reference Systems (CRS) defined in Clause 7.1 Spatial Reference Systems and the corresponding CRS identifiers in the EPSG Registry.

Table C-1: GeoPackage to EPSG CRS Crosswalk

CRS Name	CRS AUTH ID	EPSG Source
WGS 84 Geographic 3D lat/lon/hae	EPSG 4979	https://epsg.org/crs_4979/WGS-84.html [EPSG-4979]
WGS 84 Geographic 2D lat/lon	EPSG 4326	https://epsg.org/crs_4326/WGS-84.html [EPSG-4326]
WGS 84 / World Mercator	EPSG 3395	https://epsg.org/crs_3395/WGS-84-World-Mercator.html [EPSG-3395]
WGS 84 / UPS North (E,N)	EPSG 5041	https://epsg.org/crs_5041/WGS-84-UPS-North-E-N.html [EPSG-5041]
WGS 84 / UPS South (E,N)	EPSG 5042	https://epsg.org/crs_5042/WGS-84-UPS-South-E-N.html [EPSG-5042]
EGM2008 height Vertical	EPSG 3855	https://epsg.org/crs_3855/EGM2008-height.html [EPSG-3855]
WGS84 / Pseudo Mercator	EPSG 3857	https://epsg.org/crs_3857/WGS-84-Pseudo-Mercator.html [EPSG-3857]
WGS84 UTM Zone 1N	EPSG 32601	https://epsg.org/crs_32601/WGS-84-UTM-zone-1N.html [EPSG-32601]
WGS84 UTM Zone 60N	EPSG 32660	https://epsg.org/crs_32660/WGS-84-UTM-zone-60N.html [EPSG-32660]
Lambert Conic Conformal (1SP) coordinate operation method	EPSG 9801	https://epsg.org/coord-operation-method_9801/Lambert-Conic-Conformal-1SP.html [EPSG-9801]
Lambert Conic Conformal (2SP) coordinate operation method	EPSG 9802	https://epsg.org/coord-operation-method_9802/Lambert-Conic-Conformal-2SP.html [EPSG-9802]
WGS 84 + EGM2008 height Compound	EPSG 9518, EPSG 3855	EPSG-9518 [https://epsg.org/crs_9518/WGS-84-EGM2008-height.html], https://epsg.org/crs_3855/EGM2008-height.html [EPSG-3855]

Annex D: GeoPackage Use Cases.

D-1: Generic GeoPackage design considerations

Intended use

The spatial extent, vector and raster content, use of extensions, CRS, and metadata of a GeoPackage will generally be based on the intended use and the existing capabilities of the system(s) that will use the GeoPackage. The created GeoPackages could vary greatly in size from containing large area coverage of vector data or tiles to a small, purpose-built area limited to necessary data. The GeoPackage may vary in complexity from a simple container to store and exchange vector data to a tailored self-contained bundle providing data, tile, extensions, and additional tables to fully enable a targeted system or capability. This annex outlines four use cases for GeoPackage and specific steps and considerations for each.

Coordinate reference system (CRS) (see section 7.1).

1. When the GeoPackage is intended primarily for storage and transmission of vector data the geographic CRS EPSG 4326 is preferred to the other projected CRS as it allows the client to select any projected CRS available on the system.
2. When the GeoPackage is intended for storage and transmission of tile raster maps and images, a projected CRS appropriate for the area of interest should be selected. This will most often be EPSG 3395 World Mercator with Universal Polar Stereographic used at high latitudes.
3. When both vector and raster content will be included in the GeoPackage, the requestor or producer will need to determine if an unprojected geographic CRS is preferred to provide more projections options or if a specific projected CRS is preferred to direct a suitable solution.

Vector data

1. Data Preparation: Geospatial vector data is normally segmented in layers, consideration should be given to what layers and attributes are needed. Feature layers may be filtered prior to creating a GeoPackage to improve performance and reduce size. Most client applications can filter by layer but filtering by attribute is limited, so pre-filtering layers can make the data more useful to an end-user.
2. Format and Schema: Vector datasets are often stored in formats other than SQL such as shapefiles and file geodatabase. The datasets will need to be translated. Tools are available to support this (e.g. GDAL OGR2OGR). Both native and translated SQL databases may contain text descriptors or coded values (e.g. FCODEs) for the features and attributes. When a richer description of the data is desired to make it more useful to non-GIS experts, the use of the GeoPackage Schema extension can provide richer information on the dataset.

Building tables for this extension is a manual, upfront requirement but can be reused with other GeoPackages using different datasets with the same schema.

3. Styles: Vector GeoPackages may be created with or without styles and symbology resources included. The community-style extension is still an evolving document that requires detailed up-front effort and should be used primarily when both provider and consumer have validated its performance. The extension identifies processes for semantic annotation tables to link vector data to stylesheets and associated symbology as separate tables. Stylesheets may be defined in both open standard and proprietary, vendor-unique encodings. This semantic annotation can be created for multiple stylesheets and encodings. Style requirements and design consideration (beyond GeoPackage scope) include providing scale-based rules for handling multi-resolution vector data, and managing symbology files and formats as separate resources from styles to allow reuse and flexibility, depending on the use case.

a. A single stylesheet may be preferred to:

    - Ensure desired visualization is enforced (e.g. geospatial foundation for Common Operational Picture (COP) style).
    - Provide tailored GeoPackages based on client-unique rendering capabilities.

b. Multiple stylesheets and encodings may be preferred to:

    - Provide maximum encoding options for diverse clients.
    - Provide sets of compatible styles for different visualization needs (e.g. day and night modes)
    - Streamline storage and production within a central archive.

c. No style may be preferred to:

    - Keep resources (data, styles, symbology) separate with a web service.

1. Other extensions:

a. R-tree spatial index: This extension adds a new capability for spatially indexing geometry columns. The spatial index is established by creating a virtual table and a set of triggers. This index may be applied to multi-dimensional information such as geographical coordinates, rectangles, or polygons.

b. Vector tiles: Vector data may be provided as tiles using the Vector Tiles and Vector Tiles Attribute extensions. The tiles are prepared prior to packaging. Schema, styles, and R-tree may still be desired. Considerations for raster tiles may also apply.

Raster images tiles and tiles

1. Zoom level(s):

Raster tiles are defined by bounding box, CRS, and zoom levels. OGC publishes Tile Matrix Sets for common CRS, including all recommended for DGIWG profiles. Zoom levels start at a global scale and then add zoom levels at a higher resolution for pre-defined scales or by applying a process of quadtree or powers of "2". All DGIWG profiles use quadtrees as this provides better computational and visual performance. Increasing one zoom level replacing one tile at the lower zoom level with four at the next higher level, double the resolution but quadrupling the volume.

2. tileSets:

   A tileSet can consist of a single map or image which can be displayed at a fixed scale or interpolated or extrapolated to multiple scales with distortion occurring as the tile moves further from the native resolution. Alternatively, a tileSet could be composed of multiple maps or images aligned with the native resolutions to minimize distortion. Even then, problems may arise at very large scales (e.g. 1: 500) where no available map or image is suitable at the resolution.

Gridded coverage data

When gridded coverage data is used in a GeoPackage, the OGC GeoPackage extension for Gridded Coverage Data should be used. Originally intended to include elevation data such as DGIWG Gridded Elevation Data (DGED) in a GeoPackage, it is also applicable to other coverage information to include weather and environmental observations. Coverage data may be provided as a single file (e.g. Digital Terrain Elevation Data (DTED) level 2 to accompany imagery tiles) or as a tile matrix set (e.g. multi-resolution DGED aligned to increase accuracy at higher zoom levels/closer ground sample distance).

Related data

The OGC GeoPackage extension for Related Tables allows users to associate aspatial information with either vector data or raster tiles. Related Tables allow inputs such as hand-held photos, sketches, or audio files to be associated with a feature or location on the dataset or tile.

Metadata

To allow users to fully leverage GeoPackages, proper metadata is required. This benefits consumers to determine which GeoPackages in a central storage facility are most appropriate for use. It also allows users to examine the contents of mission-specific GeoPackages to understand their contents including source data and extensions provided. The DGIWG profile establishes metadata requirements to comply with the DGIWG as well as the use of national profiles or both within the same GeoPackage.

D-2: Use Case 1: Disadvantaged, mobile, and autonomous users

1. Use GeoPackage as a data dissemination format for background maps in mobile / autonomous systems.
2. Mission applications: Supports packaging data configured to mission requirements and system constraints in DDIL environments where mobile systems will preload required content prior to mission execution as web services and online updates will not be reliably available. File size, transmission capacity, and system constraints of the consumer will impact the amount of data provided and the extensions used.
3. Consumer or producer defines requirement:
    a. Single CRS selected based on area and data available.
    b. Vector data for the area identified and prepared for GeoPackage.
        - Include optional schema extension if consumer plain language query or data analytics capabilities are desired.
        - Include optional style extension if desired to share common styles or provide specific encodings for the client.
        - Include optional R-tree extension if improved organization and management of vector data is beneficial to accommodate dataset size.
        - If vector data will be provided as vector tiles, use of the tiling process is also required.
    c. Raster maps and/or images identified and prepared for GeoPackage.
        - Determine source inputs and required zoom levels.
    d. Gridded coverage data: Include optional extension if elevation data is required. Select appropriate DGED level based on mission need and capabilities of receiving system(s).
    e. Related data may be available and desired.
    f. Comply with metadata requirements: DGIWG (DMF), national (e.g. NMF), and/or other.
        i. If national metadata exists and DMF does not exist, transform national metadata to equivalent DMF.
        ii. Insert DMF into GeoPackage for the entire GeoPackage and levels of detail (vector layers, tilematrixsets, etc.) that describe the contents of the GeoPackage.
    g. Produce GeoPackage (see use case D-6)
    h. Validate GeoPackage
        i. OGC CITE Team Engine GeoPackage test, including those for DGIWG profiles, when developed, will be used to validate conformance. Validation should be conducted

on initial production and periodically revalidated.

4. Disseminate to the consumer using available online or offline transfer methods.

D-3: Use Case 2: Data exchange between processing sites

1. Use GeoPackage as an exchange format for raw data between processing sites.
2. Mission applications: Supports using GeoPackage as efficient storage and transport container for large volumes of data between network-connected processing centers. File size and bandwidth constraints are of less importance.
3. The Processing center defines requirements:
    a. Area of interest content provided.
    b. Content may be configured and segmented by data type (vector datasets, maps, images, elevation data, etc.) or may be configured by operational area (national or unit bounding box) or both
    c. One or more CRS selected based on area and data available.
    d. Vector data for the area identified and prepared for GeoPackage.
        - Include optional schema extension if consumer plain language query or data analytics capabilities are desired and not available at receiving processing center(s).
        - Include optional style extension if desired to share common styles and not available at receiving processing center(s).
        - Include optional R-tree extension if improved organization and management of vector data is beneficial to accommodate dataset size or structure.
        - If vector data will be provided as vector tiles, use of the tiling process is also required.
    e. Raster maps and/or images identified and prepared for GeoPackage
        - Determine source inputs and required zoom levels.
    f. Gridded coverage data: Include optional extension if elevation data is required. Select appropriate DGED level based on mission need and capabilities of receiving system(s).
    g. Related data may be provided if they already exist but will not normally be developed for data exchanges.
    h. Comply with metadata requirements: DGIWG (DMF), national (e.g NMF), and/or other.
        i. If national metadata exists and DMF does not exist, transform national metadata to equivalent DMF.

ii. Insert DMF into GeoPackage for the entire GeoPackage and levels of detail (vector layers, tilematrixsets, etc.) that describe the contents of the GeoPackage.

4. Produce GeoPackage for exchange with another processing site (see use case D-6).
5. Validate GeoPackage
    a. OGC CITE Team Engine GeoPackage test, including those for DGIWG profiles when developed, will be used to validate conformance. Validation should be conducted on initial production and periodically revalidated.

6 Disseminate using available online transfer methods.

D-4: Use Case 3: Storage for processing systems and map servers

1. Use GeoPackage as a storage format in a processing system or Web Map server.
2. Mission applications: Provides a standard format for raster and vector content offered by a server that facilitates access and retrieval when indexed, allows for managed updates to selected content, and supports secure import/export. File size and bandwidth constraints are of some importance.
3. Service provider designs content sharing architecture
    a. Area of interest content provided.
    b. Content may be configured and segmented by data type (vector datasets, maps, images, elevation data, etc.) or may be configured by operational area (national or unit bounding box) or both
    c. One or more CRS selected based on area and data available.
    d. Vector data for the area identified and prepared for GeoPackage.
        - Include optional schema extension if consumer plain language query or data analytics capabilities are desired.
        - Include optional style extension if desired to share common styles or provide encodings options for multiple clients.
        - Include optional R-tree extension if improved organization and management of vector data is beneficial to accommodate dataset size or structure.
        - If vector data will be provided as vector tiles, use of the tiling process is also required.
    e. Raster maps and/or images identified and prepared for GeoPackage
        - Determine source inputs and required zoom levels.

f. Gridded coverage data: Include optional extension if elevation data is required. Select appropriate DGED level based on mission need and capabilities of receiving system(s).

g. Related data may be provided if they already exist but will not normally be developed on demand for web services.

h. Define metadata requirements: DGIWG, national, and/or other.

4. Produce GeoPackage (see section D-6)

5. Validate GeoPackage

   a. OGC CITE Team Engine GeoPackage test, including those for DGIWG profiles when developed, will be used to validate conformance. Validation should be conducted on initial production and periodically revalidated.

6. Disseminate to consumers using available online transfer methods.

D-5: Use Case 4: Support autonomous data collection and retrieval

1. Use GeoPackage as an exchange format for collection and retrieval tasks using mobile or handheld devices.

2. Mission applications: Supports packaging of data from field collections such as reconnaissance and engineering surveys in formats to facilitate delivery to tasking headquarter for analysis and integration into more robust data collections.

3. Deploying headquarter producers GeoPackage to support designated operation

   a. See Use Case 1 (D-2) for production considerations.

   b. See D-6 for production workflow.

4. Deployed element gathers information in executing the mission. Information could include:

   a. Observations documented as vector data identifying key elements (Size, Activity, Location, Unit, Time, Equipment, etc.). Observations may be plotted as Points of Interest (POI) and/or entered into a field-expedient or formatted database. Plotted observations may be symbolized according to the style available to the device.

   b. Hand-held imagery or scanned graphics of the mission area. Where possible, this imagery should be tagged to the location and time it was taken and related to relevant vector observations.

   c. Vector datasets and raster products provided from liaisons with friendly or neutral entities during the mission.

   d. Precision observations and measurements of the area as coverage datasets (elevation, weather observations, hydrography data, chemical reconnaissance)

5. Collected information is prepared as a GeoPackage for transfer to analysts at mission headquarters.
    a. Core information will normally be preset to comply with GeoPackage profile requirements. Options to change core elements may be provided.
    b. Vector data will include data and metadata tables and may include schema, style, and related extension tables if enabled and used during collection.
    c. Geospatially referenced raster products will be included as individual tables or blobs or as tiles depending on the volume and format in which they were provided.
    d. Other information including handheld imagery and scanned graphics that are included as Related Tables linked to vector or raster tables as appropriate.
    e. Coverage data will use the gridded coverage extension.
6. Provide collected data back to tasking headquarters. Transfer GeoPackage for detailed analysis and integration into proper data holdings.

D-6: Generalized Workflow for generating GeoPackages

The process to produce a DGWIG compliant GeoPackage requires adding feature layers with the vector data, adding the imagery / raster data in tile matrix sets, and adding metadata for the entire GeoPackage and specific vector and / or imagery content.

The two principal workflows for GeoPackage production are described, with a section on metadata that is applicable to both workflows.

Workflow for generating a Vector GeoPackage

An end-user needs a selection of vector data layers of an area of operations; the end-user or supporting Geo subject matter expert (SME) with access to the export utility zooms selects zooms to the desired area and selects the vector layers needed. The utility executes the ogr2ogr function and accesses the database and generates a vector GeoPackage, the user is notified when the process is complete and can download the data to the appropriate file transfer mechanism. This functionality provides an indexed vector GeoPackage with all associated attributes in their coded domain form.

This process describes the basic vector GeoPackage. If extensions for schema, styles, metadata, Related Tables, and R-tree are used, they will need to be manually developed and inserted into the process flow.

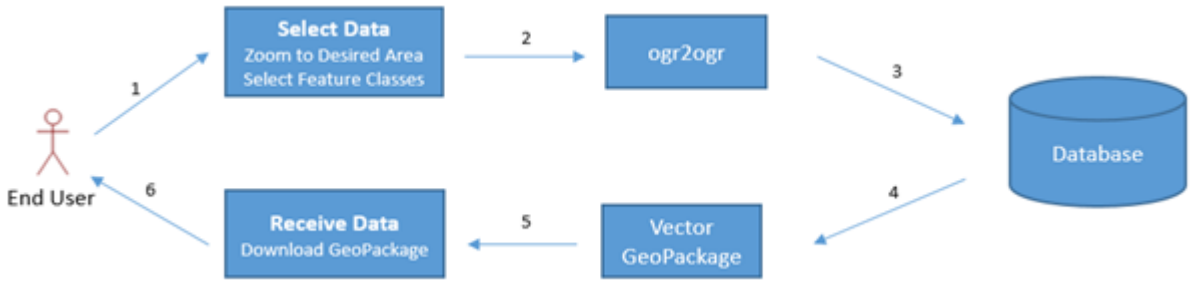

Figure D-1: Vector GeoPackage Workflow

Workflow for generating a Raster Tile GeoPackage

An end-user needs raster map products at a variety of scales over an area of operations, and an end-user or supporting Geo SME with access to the export utility zooms to the area of operation, selects the map products needed, output format, and zoom levels needed. The utility uses these Geospatial Data Abstraction Library (GDAL) functions: gdalbuildvrt to build a mosaic, gdal_translate to create the GeoPackage, and "gdaladdo" to create additional zoom levels. The gdalinfo function is used to access information about the GeoPackage. Once the GeoPackage is created, a notification is sent to the user and the user can download the data to the appropriate file transfer mechanism. The system may also provide presets so data sets may be tailored to particular operational or system requirements.

This process describes the basic raster tile GeoPackage. If extensions for metadata, gridded coverage data, and Related Tables are used, they will need to be manually developed and inserted into the process flow.

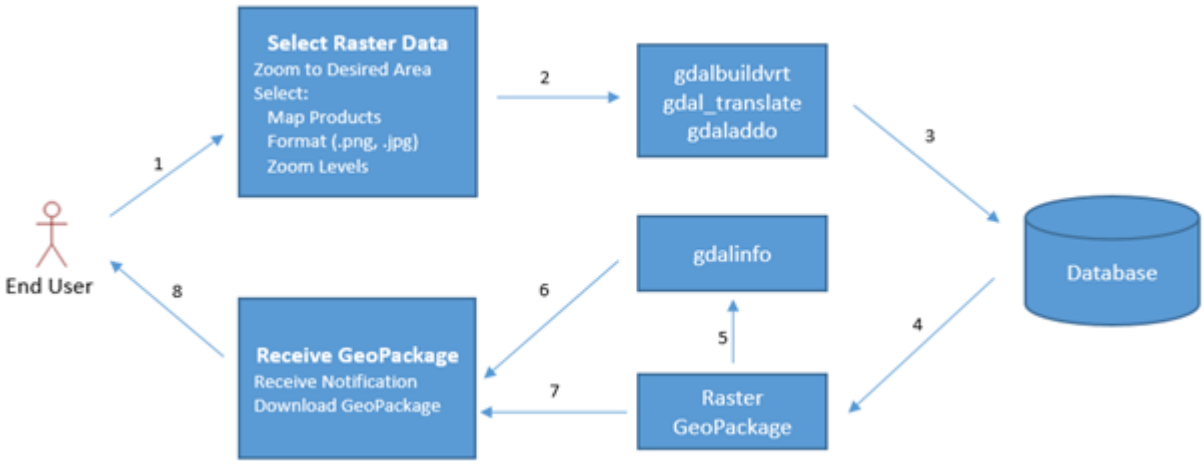

Figure D-2: Raster GeoPackage Workflow

Workflow for Metadata in GeoPackage

For DGIWG exchange, the vector and raster workflows for GeoPackage must supply at least one instanced of DGIWG Metadata Foundation (DMF) for the entire GeoPackage. Users may utilize

whatever tools are available for metadata population and update of the GeoPackage metadata tables. The use cases for the metadata workflow are depicted in Figure-D-3. Since the DGIWG profile is a multi-national implementation of an OGC standard, when a nation produces raster and/or vector data in a GeoPackage to be exchanged with other DGIWG nations (e.g. NATO members), the GeoPackage would contain national metadata in the original product as required by the nation's GEOINT standards. Before the nation's GeoPackage products are exchanged with other nations, the GeoPackage producer can translate the national metadata into the corresponding DGIWG metadata format (DMF). The producer may choose retain the GeoPackage national metadata and append the DMF content to the GeoPackage in rows of the GeoPackage metadata tables. The DMF metadata in the GeoPackage is understandable by all applications using the DGIWG profile. In addition, the systems of the producer nation and other DGIWG members have the option to view and use the national metadata information in addition to the DMF. Should the GeoPackage producer update the GeoPackage content and national metadata in the GeoPackage, a repeatable translation to DMF is performed before exchange of the next version of the GeoPackage file with DGIWG.

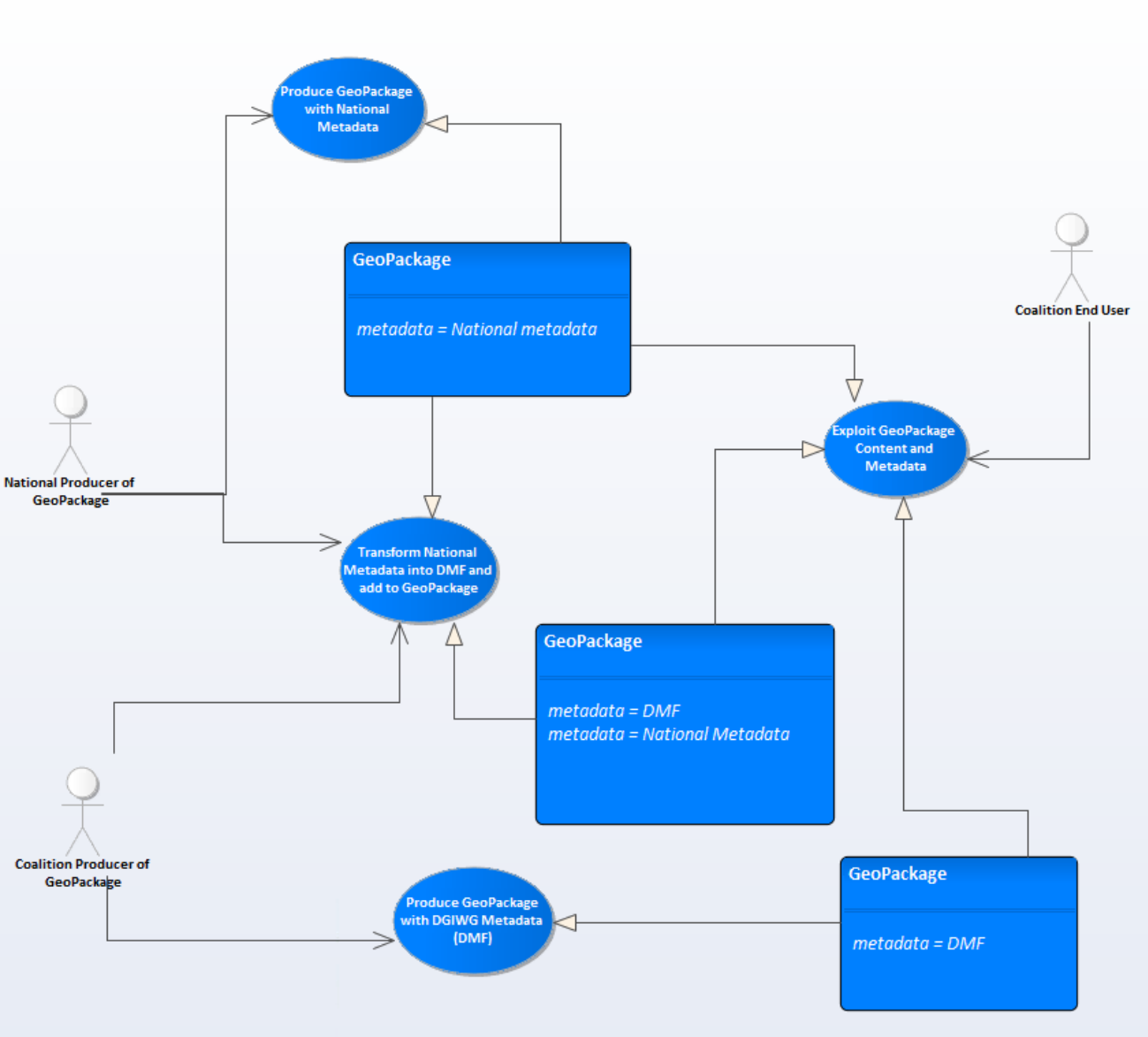

Figure D-3: GeoPackage Metadata Use Case

Annex E Footnotes and Inline References

This section contains footnotes and in-line document references from other sections of the document. Footnotes are annotated [#] in the hyperlink to this section.

[1] Per OGC Two Dimensional Tile Matrix Set, CRS84 used in GeoPackage follows EPSG:4326 with the CRS coordinates expressed in latitude, longitude order, affecting the TopLeftCorner and the BBox encoding only (Note 4 in table D.2 of 07-083r2).

[2] "WGS 84" is the srs_name specified by EPSG, which is ambiguous because it is also used for 4326. Some experts in Oil and Gas Producers (OGP) for the EPSG state that WGS 84 is fundamentally a geocentric Cartesian (X,Y,Z) system (EPSG::4978). From that, geographic 3D coordinates (including HAE) may be derived (EPSG::4979). If you drop the HAE you end up with geographic 2D (EPSG::4326).

[3] EPSG defines this as a geographic 3D CRS. This definition is encoded per WKT2 / ISO 19162. The WKT definition used here is one for a geocentric CRS with the same datum, ellipsoid, and axes. Note: the unspecified unit of measure for ellipsoidal height is meters.

[4] "WGS 84" is the srs_name specified by EPSG, which is ambiguous because it is also used for 4979. This CRS is also known as Plate Carree, Cylindrical Equirectangular, Simple Cylindrical, WGS 84 Geodetic, or WGS 84 Lat/Lon. The NSG DSE MGR name for it is "World Geodetic System 1984 - Geographic 2D". See [1] regarding CRS84.