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Envisioning a Tiled Elevation Extension for the OGC GeoPackage Encoding Standard

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i. Abstract

The GeoPackage Standards Working Group (SWG) presents a vision for storing tiled gridded elevation data in a GeoPackage.

ii. Keywords

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

ogcdoc, OGC document, GeoPackage, elevation, tiles, TIFF

iii. Preface

The GeoPackage Standards Working Group (SWG) has identified a need for the ability to store tiled gridded elevation data in a GeoPackage. This document describes the vision and proposed approach, which is an extension to the OGC GeoPackage Encoding Standard. The SWG proposes to leverage the existing structure for raster tiles using TIFF files as the container for the elevation values themselves.

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Recipients of this document are requested to submit, with their comments, notification of any relevant patent claims or other intellectual property rights of which they may be aware that might be infringed by any implementation of the standard set forth in this document, and to provide supporting documentation.

iv. Submitting organizations

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

Image Matters LLC

v. Submitters

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

Name	Affiliation
Jeff Yutzler	Image Matters LLC

1. Scope

The GeoPackage Standards Working Group (SWG) has identified a need for the ability to store tiled gridded elevation data in a GeoPackage. This capability will be used to support use cases such as the following:

- Visualization
 - 2D (hillshade, color relief, slope)
 - 3D (supporting changing view angles and level of detail)
- Analysis
 - Viewshed and line-of-sight
 - Cross-country mobility (off-road routing)
 - Site suitability and planning (slope analysis such as helicopter landing zones)
 - 3D geometry representations of features (ground-based, airspace)
 - Terrain association (associating images to mapped locations)
 - Augmented reality training

Ideally this capability will be relatively easy to implement and will be suitable for a wide variety of computing environments including the mobile/handheld computing environment.

This document describes the vision and proposed approach, which is an extension to the OGC GeoPackage Encoding Standard. The SWG proposes leveraging the existing structure for raster tiles using TIFF files as the container for the elevation values themselves.

We acknowledge that the proposed approach will not support certain applications that require a high degree of precision and/or accuracy (e.g., targeting).

2. References

2.1 Normative References

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

OGC 12-128r10 OGC® GeoPackage Encoding Standard
https://portal.opengeospatial.org/files/?artifact_id=56357

TIFF <http://partners.adobe.com/public/developer/en/tiff/TIFF6.pdf>

The Unified Code for Units of Measure (UCUM) <http://unitsofmeasure.org/ucum.html>

2.2 Informative References

GeoTIFF Format Specification Revision 1.0

<http://www.remotesensing.org/geotiff/spec/geotiffhome.html>

3. Terms and Definitions

This document uses the terms defined in Sub-clause 5.3 of [OGC 06-121r8], which is based on the ISO/IEC Directives, Part 2, Rules for the structure and drafting of International Standards. In particular, the word “shall” (not “must”) is the verb form used to indicate a requirement to be strictly followed to conform to this standard.

For the purposes of this document, the following additional terms and definitions apply.

viewshed¹

the geographical area that is visible from a location

4. Conventions

This sections provides details and examples for any conventions used in the document. Examples of conventions are symbols, abbreviations, use of XML schema, or special notes regarding how to read the document.

GPKG: GeoPackage. When followed by a number, this refers to a numbered requirement from the GeoPackage Encoding Standard.

5. Process

The SWG developed the tiled gridded approach through a series of private and public interactions between March and May 2015. The SWG email list and teleconferences were the primary means of discussion and decision making. All decisions were made by the SWG as per OGC policies and procedures. A number of votes were taken to ensure that there was consensus.

Note that the SWG members made a concerted effort to solicit and encourage public feedback. Individual decision points were opened up as issues on the GitHub repository² and this led to feedback from a number of OGC and non-OGC members. Additional feedback was solicited through the 3D GeoPackage Working Group sponsored by U.S.

¹ Wikipedia

² See <https://github.com/opengeospatial/geopackage/issues?q=is%3Aissue+milestone%3A%22Elevation+Extension%22>

Army Geospatial Center. (This working group brought together representatives from a number of U.S. Army programs with an interest in elevation data.) This public feedback helped us identify good ideas and reach consensus.

6. Proposed Approach

The SWG proposes extending the existing GeoPackage Encoding Standard and to leverage the existing structure for raster tiles. The existing tile set tables³ are used as normal with the following changes:

- A new value of “2D-gridded-coverage” is allowed in the “data_type” column of the “gpkg_contents” table.
- Create a new table called “gpkg_2D_gridded_coverage_ancillary” as described in Table 1.
- Add new columns to tile set description tables as described in Table 2 (we foresee these columns being used in other extensions which also leverage the tiles approach). When used for elevation data the new columns have the following values:
 - content: “tiled-elevation”
 - ancillary_table: “gpkg_elevation_ancillary”
 - ancillary_key: (foreign key to row in gpkg_elevation_ancillary)
- Instead of JPEG or PNG files, elevation data is stored in TIFF files. These files are constrained as follows:
 - Either 16-bit signed integer or 32-bit floating point
 - One sample per pixel
 - LZW compression may be used
 - No subfiles or internal tiles
- Use ISO metadata (optional) to encode other details about the elevation data.

7. Next Steps

The SWG proposes the following next steps:

- Discuss this proposal in the broader community (outside the SWG itself) to reach a consensus on approach.
- Plan and perform interoperability experiments that allow implementers the opportunity to develop compliant software and demonstrate its interoperability (this could be as part of OWS 12 or in an independent interoperability experiment or plugfest)
- Document the extension as part of an updated version of the GeoPackage Encoding Standard or as a separate document

³ See sections 2.2.6, 2.2.7, and 2.2.8 of the GeoPackage Encoding Standard

8. Frequently Asked Questions

Q: What about GeoTIFF?

A: The SWG was just looking for a simple container to hold the elevation values. The geo-referencing is handled by the tile structure so GeoTIFF would have been redundant. TIFF is self-describing (a plus for many SWG members) but is otherwise a fairly simple format with broad API support (libtiff, etc.). Requiring GeoTIFF would have significantly increased the cost and complexity of the approach. This approach is also consistent with other OGC standards such as Web Map Tile Service (WMTS).

Q: What about supporting other types of coverages?

A: The SWG foresees this approach being used for other types of coverages (for example, in the weather domain). However, since elevation is the top priority, the SWG chose to focus on that single use case for now. Once the approach is proven, it should be easy to support other types of coverages as well.

Annex A Proposed Extension Clauses

A.1 MIME Type

Req1 (extends GPKG 35, GPKG 36): A GeoPackage that contains a tile pyramid user data table MAY store tile_data in MIME type image/tiff. The content of the data table SHALL NOT be raster tiles as per the core specification and SHALL be described by an extension such as this one.

A.2 TIFF Encoding

Req2 (constrains TIFF Section 2): A TIFF file storing tiled gridded elevation data SHALL have one sample per pixel.

Req3 (constrains TIFF Section 2): A TIFF file storing tiled gridded elevation data SHALL have one of the following two data types: 16-bit signed integer (SSHORT – 8) OR 32-bit floating (FLOAT – 11).

Req4: A TIFF file storing tiled gridded elevation data MAY use the LZW compression option as per TIFF Section 13. Client applications SHALL support this option.

Req5 (constrains TIFF Section 2): A TIFF file storing tiled gridded elevation data SHALL NOT contain multiple images per TIFF file.

Req6 (constrains TIFF Section 15): A TIFF file storing tiled gridded elevation data SHALL NOT contain internal tiles as per TIFF Section 15.

A.3 Table Definitions

Req7: A GeoPackage that contains tiled gridded elevation data SHALL contain a gpkg_2D_gridded_coverage_ancillary table or view as per Table 1.

Table 1 – gpkg_2D_gridded_coverage_ancillary Table Definition

Column Name	Type	Description	Null	Default	Key
id	INTEGER	Autoincrement primary key	no		PK
datatype	TEXT	'float' or 'integer'	no		
uom	TEXT	unit of measure, as per UCUM	no		
scale	REAL		yes	1	
offset	REAL		yes	0	
precision	REAL		yes	if datatype is	

				integer then 1, otherwise undefined	
data_null	REAL		yes		
data_missing	REAL		yes		

Req8 (extends GPKG 37): A GeoPackage that contains tiled gridded elevation data SHALL contain a gpkg_tile_matrix_set table or view as per Table 2.

Table 2 – Updated Tile Matrix Set Table Definition

Column Name	Type	Description	Null	Default	Key
table_name	TEXT	As Per Table 8 in OGC 12-128r10	no		PK, FK
srs_id	INTEGER	As Per Table 8 in OGC 12-128r10	no		FK
min_x	DOUBLE	As Per Table 8 in OGC 12-128r10	no		
min_x	DOUBLE	As Per Table 8 in OGC 12-128r10	no		
min_x	DOUBLE	As Per Table 8 in OGC 12-128r10	no		
max_y	DOUBLE	As Per Table 8 in OGC 12-128r10	no		
content	TEXT		yes	tiles	
ancillary_table	TEXT		yes	N/A	
ancillary_id	INTEGER		yes	N/A	

A.4 Table Values

Req9 (extends GPKG34): The gpkg_contents table SHALL contain a row with a “data_type” column value of “2D-gridded-coverage” for each tile pyramid containing tiled gridded elevation data.

Req10 (extends GPKG39): Values of the gpkg_tile_matrix_set table_name column SHALL reference values in the gpkg_contents table_name column for rows with a data_type of “2D-gridded-coverage”.

Req11 (extends GPKG40): For each tile pyramid user data table containing tiled gridded elevation data, rows in the `gpkg_tile_matrix_set` table SHALL contain values as denoted in Table 3.

Table 3 – Required Column Values in `gpkg_tile_matrix_set`

Column Name	Value
content	tiled-elevation
ancillary_table	gpkg_2D_gridded_coverage_ancillary

Req12: For each row in the `gpkg_tile_matrix_set` table that references tiled gridded elevation data, the value of the `ancillary_id` column SHALL reference a value in the `gpkg_2D_gridded_coverage_ancillary` id column.