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## OGC GeoPackage Plugfest Discussion Paper

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**i. Abstract**

This OGC discussion paper presents the results of the GeoPackage Plugfest. In this initiative, participants had the opportunity to evaluate the compliance and interoperability of software that produces and consumes GeoPackages containing tiled raster data.

**ii. Keywords**

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

ogcdoc, OGC document, GeoPackage, GPKG, plugfest, interoperability, tiles

**iii. Preface**

The GeoPackage Encoding Standard defines an open, non-proprietary, platform-independent SQLite container for distribution and direct use of geospatial data, including vector features and tile matrix sets of earth images and raster maps at various scales. OGC members and other non-members are invited to participate in a Plugfest to test the use of the GeoPackage (GPKG) standard as a container for tiled imagery and to produce a shareable GPKG file with tiled imagery content.

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

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**iv. Submitting organizations**

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

U.S. ARMY GEOSPATIAL CENTER

IMAGE MATTERS LLC

**v. Submitters**

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

Name	Affiliation
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Micah Brachman	RGI, for U.S. Army Geospatial Center

## 1. Scope

This OGC Discussion Paper documents the OGC GeoPackage Plugfest for tiled raster data.

The goal of this Plugfest was to determine the following:

- Whether providers produce compliant GeoPackages containing tiled raster data
- Whether clients behave as expected after loading compliant GeoPackages
- What changes need to be made to the GeoPackage implementation standard to improve interoperability
- What testing methods are needed to ensure interoperability

## 2. References

### 2.1 Normative References

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

OGC 06-121r9, *OGC Web Service Common Implementation Specification*, Version 2.0.0, 2010.

OGC 07-057r7, *OpenGIS Web Map Tile Service Implementation Standard*, Version 1.0.0, 2010.

OGC 12-128r10, *OGC® GeoPackage Encoding Standard*, Version 1.0, 2013.

### 2.2 Informative References

The following informative documents are referenced by this document but do not 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.

*National System for Geospatial-Intelligence (NSG) GeoPackage Encoding Standard 1.0 Implementation Interoperability Standard (DRAFT)*, 2015.

## 3. Terms and Definitions

This document uses the terms defined in Sub-clause 5.3 of [OGC 06-121r9], 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.

**DARPA**

Defense Advanced Research Projects Agency

**ERDC**

**U.S. Army Corps of Engineers, Engineer Research and Development Center**

**ETS**

Executable Test Suite

**GPKG**

GeoPackage

**Plugfest**

A Plugfest is an event where vendors cooperatively test (and possibly refine) their OGC-based products in a hands-on engineering setting. Plugfests are used to (1) assess the degree to which different products in the marketplace interoperate together based on their implementation of OGC standards, and (2) advance the interoperability of geospatial products and services based on OGC standards in general or within specific communities.

**RGi**

Reinventing Geospatial Inc., a contractor to the U.S. Army Corps of Engineers

**SQL**

Structured Query Language

**SQLite**

A software library that implements a self-contained, serverless, zero-configuration, transactional SQL database engine.

**XML**

Extensible Markup Language

## **4. Plugfest Results**

The GeoPackage Plugfest participants performed a series of interoperability experiments. The goal of these sessions was to test OGC GeoPackages submitted to the Plugfest to determine if they comply with the OGC GeoPackage encoding standard and are interoperable across several software platforms. Compliance testing was performed using an executable test suite (ETS) built by RGi.

Following are the details of the four items identified in the scope.

- Whether providers produce compliant GeoPackages containing tiled raster data

**Success.** Providers were generally able to produce GeoPackages that came close to standard compliance. The compliance issues that we observed were typically minor and did not appear to pose a threat to interoperability.

- Whether clients behave as expected after loading compliant GeoPackages

**Issue.** Compliant GeoPackages were not necessarily interoperable. There were numerous instances of tiles not displaying as expected in integrated clients. We believe this may be due to confusion regarding how tiles are to be indexed. The GeoPackages assessed for the Plugfest were generally created in two steps: 1) native imagery is tiled as JPEG or PNG images and structured as tile pyramids such as those defined for Tile Map Service (TMS) or Web Map Tile Service (WMTS) and 2) these tile structures are then re-indexed to meet the requirements of the GeoPackage standard. GeoPackage producers must first establish the tile origin (i.e. upper left vs. lower left) of the initial tile structure and then may need to correctly translate from globally referenced, absolute tile index numbers (e.g. TMS) to the GeoPackage tile index numbers which are referenced relative to the data bounding box and which restart at zero for each zoom level.

- What changes need to be made to the GeoPackage implementation standard to improve interoperability

**Suggested Changes.** To mitigate future GeoPackage interoperability issues we believe that implementation profiles should be created to ensure that GeoPackages serve their purpose and are fit for intended use. Implementation profiles should align to specific tile scale sets. For example, a Web Mercator profile would be used with the GoogleMapsCompatible (urn:ogc:def:wkss:OGC:1.0:GoogleMapsCompatible) tile scale set (see Appendix E.4 of [OGC 07-057r7])<sup>1</sup>.

An implementation profile should include, but not necessarily be limited to, the following:

1. Supported Spatial Reference System(s)
2. Tile sizes
3. Zoom levels (names and meters/pixel)
4. Tile pyramid design (including indexing scheme)
5. Tile alignment
6. Tile matrix extent

- What testing methods are needed to ensure interoperability

**Not successful.** This item is unresolved as we were unable to attain substantial interoperability between implementations.

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<sup>1</sup> A National System for Geospatial-Intelligence (NSG) implementation profile is currently being developed under a separate initiative.

We believe that another interoperability experiment should be performed, ideally in conjunction with the development of one or more implementation profiles. Contributors to the U.S. National System for Geospatial-Intelligence (NSG) are currently developing a GPKG implementation profile. We encourage NSG developers (and any other communities of interest that develop an implementation profile) to conduct interoperability experiments as their profile is advanced.

Developers may refer to the GPKG produced by RGi, which passed all of the Plugfest testing. It is available on the on the OGC Portal<sup>2</sup> along with available tests. **Additionally, it has been linked on geopackage.org<sup>3</sup>.**

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<sup>2</sup> [https://portal.opengeospatial.org/files/?artifact\\_id=60628](https://portal.opengeospatial.org/files/?artifact_id=60628)

<sup>3</sup> <http://www.geopackage.org/#sampledata>



## Annex A – Experiments

This section documents the details of the two interoperability experiments that were performed.

Note that since this plugfest did not attain the desired results, we will not publish the identities of the GeoPackage providers (other than RGi as mentioned above). We see no benefit to identifying these organizations when the lack of desired interoperability is directly attributable to the standard itself.

### A.1 Experiment 1

The GeoPackage Plugfest Working Group performed interoperability testing on 14 and 17 November 2014. Eight GeoPackages containing raster tile data were provided to the working group for testing. As summarized in Table 1, the following tests were conducted:

1. Inspect the GPKG in a SQLite viewer
2. Load the GPKG in DARPA TransApp Panthr Tiles v4.8.2.5
3. Inspect the available zoom levels in Panthr Tiles
4. Perform GeoLocation in Panthr Tiles
5. Load the GPKG in Nett Warrior 2.0.6.x
6. Load the GPKG in ERDC GPKG Viewer vx.x.x
7. Perform GeoLocation in the ERDC GPKG Viewer
8. Test the GPKG using v1.0 of the ETS

*Table 1 – Test Results in Experiment 1*

T#\GPKG #	1	2	3	4	5	6	7	8	Summary <sup>4</sup>
1	P	P	P	F <sup>5</sup>	P	P	P	P	1/0/7
2	P	PF	P		PF	F	F	F	3/2/2
3	P	P	P		P	F	P	P	2/0/5
4	P	PF <sup>6</sup>	P		PF	F	F	F	3/2/2
5	PF	PF	P		F	F	F	F	3/2/1
6	F	PF	P		P	F	F	F	4/1/2
7	F	P	P		PF	F	F	F	4/1/2
8	PF	PF	P		PF	PF	PF	PF	1/6/1
<b>Summary<sup>3</sup></b>	2/2/4	0/3/5	0/0/8	1/0/0	1/4/3	6/1/1	5/1/2	5/1/2	

<sup>4</sup> Failures / Partial Failures / Passes

<sup>5</sup> This GPKG did not have any tiled data and therefore was not tested further.

<sup>6</sup> In some cases the Geolocation appears to be displaced 1km to the West. The reason for this was not clear.

As presented in Table 2, seven of the eight (87.5%) GeoPackages violated one or more of the requirements in the OGC GeoPackage specification. Only one provider passed all tests but four providers passed at least some of the tests. Most of the standard requirements that were violated were relatively minor and should not affect interoperability, but larger issues remain in determining how the bounding box is used and in standardizing the tile-indexing scheme.

*Table 2 – Executable Test Suite Failures in Experiment 1*

<u>Requirement</u>	<u># of Failures</u>	<u>Summary</u>	<u>Implications</u>
2	3	Application ID not set	Minor
5	1	Data type of TEXT(1) not allowed	Minor
11	4	No default SRS values of -1 and 0	Minor
13	3	Last changed column type	Minor
13	1	Column default of " instead of ""	Minor
15	2	Dates need three-digit milliseconds	Minor
34	1	Must be powers-of-two zoom	Moderate -- may lead to misaligned tiles

In addition, defects were discovered in the client applications. These were reported to the vendors.

## A.2 Experiment 2

After reporting the results of Experiment 1, the GeoPackage Plugfest Working Group requested that the original eight data providers produce updated GeoPackages to address requirement failures. Three of the data providers responded to this data call, and the GeoPackage Plugfest participants performed a second round of interoperability testing on 23 January 2015. The following tests were conducted:

1. Inspect the GPKG in a SQLite viewer
2. Load the GPKG in DARPA TransApp Panthr Tiles v4.8.2.5
3. Inspect the available zoom levels in Panthr Tiles
4. Perform GeoLocation in Panthr Tiles
5. Load the GPKG in Nett Warrior 2.0.6.x
6. Load the GPKG in ERDC GPKG Viewer vx.x.x
7. Perform GeoLocation in the ERDC GPKG Viewer
8. Test the GPKG using v1.1 of the ETS

Three GeoPackages containing raster tile data were provided to the working group for testing. These were tested as summarized in Table 3 and Table 4. None of the updated GeoPackages passed all tests. All of these GeoPackages are very close to meeting the OGC GeoPackage Standard, thus the major interoperability problem continues to be inconsistencies in how the tile pyramids are indexed.

Table 3 – Test Failures in Experiment 2

Test	Failures / Partial Failures / Passes	Summary
1	0/0/3	
2	1/2/0	One GPKG did not open, other two had tile offsets
3	2/0/1	
4	3/0/0	
5	1/2/0	One GPKG did not open, other two had tile offsets
6	1/2/0	One GPKG did not open, other two had tile offsets
7	3/0/0	
8	See below	See below

Table 4 – Executable Test Suite Failures in Experiment 2

Requirement	# of Failures	Summary	Implications
13	3	<p>"A GeoPackage file SHALL include a gpkg_contents table per clause 1.1.3.1.1, Table 4 and Table 21."</p> <p><b>Required column last_change is defined as:</b>  <i>Type: DATETIME, not null: true, default value: strftime("%Y-%m-%dT%H:%M:%fZ',CURRENT_TIMESTAMP), primary key: false, unique: false</i></p> <p><b>but should be:</b>  <i>Type: DATETIME, not null: true, default value: \s*strftime\s*(\s*["']%Y-%m-%dT%H:%M:%fZ["']\s*,\s*["']now["']\s*)\s*, primary key: false, unique: false</i></p>	Moderate -- *this is a change made to the original OGC spec
14	1 (warning)	<p>"The table_name column value in a gpkg_contents table row SHALL contain the name of a SQLite table or view."</p> <p>The table_name value in gpkg_contents table is invalid for the table: water</p>	Minor
60	1	<p>"A GeoPackage MAY contain a table or updateable view named gpkg_data_column_constraints. If present it SHALL be defined per clause 2.3.3.1.1 Table 12 and Table 32. "</p> <p><b>Required column:</b>  gpkg_data_column_constraints.maxIsInclusive is missing</p>	Moderate
82	1 (warning)	<p>"Each extension_name column value in a gpkg_extensions row SHALL be a unique case sensitive value of the form &lt;author&gt;_&lt;extension_name&gt; where &lt;author&gt; indicates the person or organization that developed</p>	Minor

		<p>and maintains the extension. The valid character set for &lt;author&gt; SHALL be [a-zA-Z0-9]. The valid character set for &lt;extension_name&gt; SHALL be [a-zA-Z0-9_]. An extension_name for the ?gpkg? author name SHALL be one of those defined in this encoding standard or in an OGC Best Practices Document that extends it."</p> <p>The following extension_name(s) are invalid:" "</p>	
83	1 (warning)	<p>"The definition column value in a gpkg_extensions row SHALL contain or reference the text that results from documenting an extension by filling out the GeoPackage Extension Template in GeoPackage Extension Template (Normative)."</p> <p>The following table_name values in gpkg_extension table have invalid values for the definition column: Water, TractCentroids, Streets, Signposts, Shoreline, RestrictedTurns, Parks, MajorRoads, Hospitals, Highways, FireStations.</p>	Minor

## Annex B: Revision History

<b>Date</b>	<b>Version</b>	<b>Editor</b>	<b>Description</b>
Nov 2014	0.0.1	Jeff Yutzler	First round of experiment
2 Feb 15	0.0.2	Micah Brachman	Second round of experiment
19 Feb 15	0.0.3	Jeff Yutzler	Conclusions
23 Feb 15	0.0.4	Micah Brachman	Review
23 Feb 15	0.0.5	Jeff Yutzler	Review
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5 Mar 15	0.0.7	Lew Leinenweber	Review
9 Mar 15	0.0.8	Jeff Yutzler	Resolving comments
12 May 15	0.0.9	Jeff Yutzler	Resolving comments
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