OGC Geospatial to the Edge Plugfest Engineering Report

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Chapter 1. Summary

The Geospatial to the Edge Interoperability Plugfest, co-sponsored by Army Geospatial Center and the National Geospatial-Intelligence Agency (NGA/CIO&T) brought together technology implementers and data providers to advance the interoperability of geospatial products and services based on OGC profiles. Servers and data available via GeoPackage, Web Feature Service (WFS), Web Map Service (WMS) and Web Map Tile Service (WMTS), all following National System for Geospatial Intelligence (NSG) profiles were exercised and improved in various clients. Compliance Tests were executed and advanced based on feedback from the participants.

1.1. Motivation

The geospatial communities supporting defense, emergency response, and intelligence rely on geospatial data and open standards to accomplish their mission. To make sharing of data meet their specific needs, they used profiles. Profiles provide strict implementation guidance to ensure interoperability of geospatial systems in these highly specialized and demanding environments. Implementations following profiles compliant to open standards support mission critical operations for executing effectively and efficiently.

A Plugfest, an initiative of the OGC Innovation Program, provides the right venue for sponsors and technology implementers to come together in a collaborative agile process to solve geospatial challenges. The Plugfest assisted tool enhancement and provided guidance to improve the delivery of enterprise geospatial data to end users. In this initiative, a Plugfest was used to bring more than thirteen data/service producers and clients of data following NSG profiles. It help discovered implementation issues and advance executable test suites.

1.2. Prior-after comparison

Before the Plugfest very few implementations were able to interact with NSG profiles. This is commonly the case when communities want to restrict a rule from the base standard or want to extend what the base standard offers. The support for these profiles is not commonly a feature that comes packaged in software products. After the Plugfest more implementations were available implementing the NSG profiles.

The profiles implemented in the Plugfest had corresponding executable test suites. These profiles test suites were in beta by the end of the initiative, ready to be move forward for public release by the OGC Technical Committee. Feedback related to the executable test suites was provided by the participants. In particular, the GeoPackage test was improved during the Plugfest.

1.3. Recommendations for future work

Activities like this Plugfest should be performed for new profiles or new standards allowing participants to come together to solve interoperability issues. The result, of high value to the geospatial community, is improvement of the standards and advancement of test suites.

Recommendations about implementing the profiles in regards to the specific profiles are detailed in the Results and Recommendations Section.

1.4. Document contributor contact points

All questions regarding this document should be directed to the editor or the contributors:

Contacts

Name	Organization
Luis Bermudez	OGC

1.5. Foreword

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.

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.

Chapter 2. References and abbreviated terms

2.1. References

The following normative documents are referenced in this document.

- NSG GeoPackage 2.1 (raster and vector data), based on the OGC GeoPackage 1.1 standard: https://nsgreg.nga.mil/doc/view?i=4379
- NSG WMS 1.0 (raster data), based on the OGC WMS 1.3 standard: https://nsgreg.nga.mil/doc/view?i=4209&month=11&day=13&year=2017
- NSG WMTS 1.1 (raster data), based on the OGC WMS 1.0 standard: https://nsgreg.nga.mil/doc/view?i=4448
- NSG WFS 1.0 (vector data), based on the OGC WFS 2.0 standard: https://nsgreg.nga.mil/doc/view?i=4388&month=11&day=17&year=2017

2.2. Abbreviated terms

- CSV Comma-separated values
- DoD United States Department of Defense
- ESA European Space Agency
- GEOINT Geospatial Intelligence
- GGDM Ground-Warfighter Geospatial Data Model
- GMES Global Monitoring for Environment and Security
- GML Geography Markup Language
- IC Intelligence Community
- JSON JavaScript Object Notation
- NAS NSG Application Schema
- NSG National System for Geospatial Intelligence
- NSGM National System for Geospatial-Intelligence Manual
- OGC Open Geospatial Consortium
- WFS Web Feature Service
- WMS Web Map Service
- WMTS Web Map Tile Service

Chapter 3. Overview

This Plugfest, co-sponsored by Army Geospatial Center and the National Geospatial-Intelligence Agency (NGA/CIO&T), brought together technology implementers and data providers to advance the interoperability of geospatial products and services based on community profiles. The Plugfest assisted on tool enhancement and provided guidance to improve the delivery of enterprise geospatial data to end users.

Examples of how end user communities will benefit form this work are:

- First responders, relief workers and fire fighters preparing for and operating in austere network environments.
- Emergency planners and managers supporting hurricane, wildfire, and earthquake preparedness, relief/response activities and damage assessment.
- Soldiers/warfighters during planning and executing operations specifically in disconnected, intermittent, and limited network environments.

The geospatial communities supporting defense, emergency response, and intelligence rely on geospatial data and open standards to accomplish their mission. To make sharing of data meet their specific needs, they used profiles. Profiles provide strict implementation guidance to ensure interoperability of geospatial systems in these highly specialized and demanding environments. Non-compliance to open standards profiles prohibits mission critical operations from executing effectively and efficiently.

NOTE

OGC Recently adopted a better term to refer to **Profiles** that also extend the base standard. NSG Profiles are of these type and in the future these types of profiles should be referred as **Profiles with Extension**. Profiles restrict (remove) options (e.g. file formats or coordinate reference systems) that already exist in the base specification. Extensions add options and/or capabilities that are not included in the base specification.

Additionally, members of the Intelligence Community (IC), United States Department of Defense (DoD), non-DoD/IC Federal agency members of the NSG, international partners, state/local municipalities, and Native American tribal organizations that are responsible for the operation, acquisition and/or development of systems and applications which collect, procure, produce, serve, exchange, or use Geospatial Intelligence (GEOINT) data are mandated to comply NSG implementation standards (NSGM 3202). The support of these profiles affect government acquisition decisions to ensure that all systems within the government can communicate appropriately. [From GEOINT Functional Manager Standards Assessment (GFMSA) Program Manual, NSGM 3202, June 2016]

A Plugfest, an initiative of the OGC Innovation Program provides the right venue for sponsors and technology implementers to come together in a collaborative agile process to solve geospatial challenges. A Plugfest provides the scenarios and testing environment to advance implementation of profiles in commercial and open source software products. A Plugfest allows

organizations to test and validate that their software products can interoperate with other products implementing the same standards.

Chapter 4. Plugfest description

4.1. Goal

The goal of the Plugfest was to increase interoperability of information systems using community profiles. The Plugfest assisted on tool enhancement and provided guidance to improve the delivery of enterprise geospatial data to end users.

4.2. Profiles

The profiles used in the initiative were:

- NSG GeoPackage 2.1 (raster and vector data), based on the OGC GeoPackage 1.1 standard: https://nsgreg.nga.mil/doc/view?i=4379
- NSG WMS 1.0 (raster data), based on the OGC WMS 1.3 standard: https://nsgreg.nga.mil/doc/view?i=4209&month=11&day=13&year=2017
- NSG WMTS 1.1 (raster data), based on the OGC WMS 1.0 standard: https://nsgreg.nga.mil/doc/view?i=4448
- NSG WFS 1.0 (vector data), based on the OGC WFS 2.0 standard: https://nsgreg.nga.mil/doc/view?i=4388&month=11&day=17&year=2017

4.3. Plugfest participation roles

The participants in the Plugfest took the following roles:

- **Data Providers** were organizations providing data sources either serving it via OGC services or providing file.
- **Service Providers** were organizations that produced services for clients to access.
- **Client Providers** were organizations that provided clients that consumed GeoPackage data and services to be used for a specific purpose.

4.4. Sprints

Sprints happened virtually allowing participants around the world to participate and to minimize costs related to travel. Each sprint lasted for 1 week. During the sprint week participants were available to respond to inquiries posted by other participants. In the sprint time clients performed a set of operations following a scenario and documented their success and failures.

Two sprints were planned on this Plugfest.

Sprint 1 tested existing commercial and/or open source products against the scenarios. A limited

(not for public dissemination) report on Sprint 1 findings, not revealing vendor information, was shared with the Sponsors and relevant OGC Standards Working Groups. The findings (need for improvement in data structure, servers and clients) was properly documented.

Sprint 2 Occurred 3 months after the Sprint 1. It repeated the test performed in Sprint 1. Participants had three months to improve their software to better create the GeoPackage files and improve their services and clients based on the feedback from Sprint 1.

4.5. Schedule

- March 6 - Participants kickoff (Pre-sprint clarification open to registered participants)
- March 30 - Update scenarios
- April 16 - Information about sources (data and servers) was provided to OGC
- April 20 - Data and Servers ready for Sprint 1
- April 23-27 - Sprint 1 clients testing
- April 30-May 11 - Compilation of results by OGC
- April 30-July 16 - Discussions in GitHub issue tracker
- July 16 - Information about data and servers was provided to OGC
- July 20 - Data and Servers ready for Sprint 2 (Improved services based on feedback from Sprint 1)
- July 23-Aug 2 - Sprint 2 clients testing
- September 9 - Draft report
- September 28 - Report submission to OGC TC for public release approval

4.6. Data

Two types of data, based on NSG Profiles, were used in the initiative:

- **Vector data** used to create, publish and ingest GeoPackage files as well as to publish to and ingest data from WFS servers.
- **Raster data** used to exercise WMS and WMTS servers.

4.6.1. Vector data

Vector data used in the Plugfest was based on the Ground-Warfighter Geospatial Data Model (GGDM 3.0), which is based on the NSG Application Schema (NAS) version 7. Various files were created using the GGDM 3.0 schema, which were used by participants to create GeoPackages or vector files that were served via a WFS.

The NAS Model Entity Catalog provides a set of features, attributes and enumeration values to be

used when encoding vector information. It was provided as an Excel File. It was used by participants to understand better the feature types (semantics) of the data.

The data region was based on Puerto Rico. The datasets contained the following layers:

- USGS Puerto Rico data for roads and trails, airports, rivers, selected buildings, built-up areas, and some surface areas including runways, counties, a forest, cemeteries and conservation areas.
- US Transportation Data from which Heliport and Water Aerodrome points pulled from airport data; ports and anchorages pulled from port data.
- US Maritime data for maritime limits restricted to Puerto Rico area.
- US Census Bureau coastlines restricted to land/water boundaries for the Puerto Rico area.

The Data was available for download in the following formats:

- Geography Markup Language (GML)
- Composite ArcGIS (10.1+) File Geodatabase in flattened mode with feature datasets and with no subtypes
- JavaScript Object Notation (JSON)
- GeoJSON
- Comma-separated values (CSV)

The list of features types contained in the source files was as follows:

- ADMINISTRATIVE_SUBDIVISION_S
- BUILDING_P
- BUILT_UP_AREA_P
- CEMETERY_S
- CONSERVATION_AREA_S
- DAM_C
- DAM_S
- DATASET_S
- DOLPHIN_P
- ENTITY_COLLECTION_METADATA_S
- FORESHORE_S
- FOREST_S
- GAUGING_STATION_P

- HELIPORT_P
- INLAND_WATERBODY_S
- LAND_AERODROME_P
- LAND_WATER_BOUNDARY_C
- MARITIME_LIMIT_C
- MILITARY_INSTALLATION_S
- NAVIGABLE_CANAL_S
- PARK_S
- PIPELINE_C
- PORT_P
- REEF_C
- RIVER_C
- RIVER_S
- ROAD_C
- ROCK_FORMATION_P
- RUNWAY_S
- SOIL_SURFACE_REGION_S
- TRAIL_C
- TUNNEL_C
- WATER_AERODROME_P
- WATER_WELL_P

4.6.2. Raster data

The raster data was based on the Sentinel 2A Multispectral Instrument (MSI), made available by the European Space Agency (ESA) within the Global Monitoring for Environment and Security (GMES) programme. The true color composites (red, green, blue) from the orthorectified Level-lC products were used to generate map data for WMS, WMTS, and GeoPackage files.

The Sentinel data are freely available through the Copernicus Open Access Hub. The data used in the Plugfest corresponded to the region of Puerto Rico and the True Color Image (TCI).

The Table below lists the subset Product ID's from the Sentinal 2A mission that were used by the data providers. From each image set, the `*TCI.jp2` image was used to create the output products. Participants used the Copernicus Hub recommend API script to download each dataset.

Product ID	Unique ID (API access)
S2B_MSIL1C_20171209T150709_N0206_R082_T19QFA_20171209T195400	a6a9d67d-fbd5-47be-b5c7-92d680b5028b
S2B_MSIL1C_20171209T150709_N0206_R082_T19QGA_20171209T195400	2c6a75a4-7327-45b0-b493-ea9a40982b13
S2B_MSIL1C_20171209T150709_N0206_R082_T19QGV_20171209T195400	2590351c-a1ae-4592-9b3d-83358d8b13f1
S2B_MSIL1C_20171209T150709_N0206_R082_T19QHA_20171209T195400	87f334c4-1993-409a-bd46-79a58a8ba243
S2B_MSIL1C_20171209T150709_N0206_R082_T19QHV_20171209T195400	96c5aee0-68d9-4c11-8182-e78b8adca7c1
S2A_MSIL1C_20161219T150712_N0204_R082_T19QFV_20161219T150714	31d6900f-3164-4243-84f8-84d39982a4fe

Table 1. Sentinel 2 Product IDs

After setting up an account, the unique id can be plugged in the URL string to form the link for download. For example:

```
https://scihub.copernicus.eu/dhus/odata/v1/Products('a6a9d67d-fbd5-47be-b5c7-92d680b5028b')/$value
```

After downloading the data the participants were responsible for the merge and tiling of this imagery data as per the NSG specifications for raster data.

4.7. Data consumer testing reports during sprints

4.7.1. Organizations acting as clients/users

The following organizations acted as clients/users of the Plugfest.

- AGC-Nett Warrior
- AGC-Sitaware
- Distributed Common Ground System–Army (DCGSA)
- Compusult
- Envitia
- Esri
- Image Matters
- U.S. Naval Research Laboratory (NRL)
- Visual Awareness Technology and Consulting (VATC)

4.7.2. Data, services and templates

The Data and Services were provided by:

- AGC-ENFIRE
- Aviation and Missile Research Development and Engineering Center (AMRDEC)
- Compusult
- Distributed Common Ground System–Army (DCGSA)
- Esri
- GeoSolutions
- U.S. Naval Research Laboratory (NRL)
- Visual Awareness Technology and Consulting (VATC)

The name of the sources were anonymized. The links and templates used in Sprint 1 are detailed in the table below.

Source type	Source short name (with link)	Template used to report
GeoPackage_Vector	GeoPackage_Vector_Apollo	GeoEdgePlugfest-S1-GeoPackageVector-sourceName-orgName
GeoPackage_Raster	GeoPackage-Raster_Jupiter	GeoEdgePlugfest-S1-GeoPackageRaster-sourceName-orgName
WMS	WMS_Mercury	GeoEdgePlugfest-S1-WMS-sourceName-orgName
WMS	WMS_Mars	GeoEdgePlugfest-S1-WMS-sourceName-orgName
WMTS	WMTS_Pluto	GeoEdgePlugfest-S1-WMTS-sourceName-orgName
WMTS	WMTS_Oberon	GeoEdgePlugfest-S1-WMTS-sourceName-orgName

The links and templates used in Sprint 2 are detailed in the table below.

Source type & Source short name	Template to provide feedback
GeoPackage_Vector_Apollo	GeoEdgePlugfest-S2-GeoPackageVector-sourceName-orgName.doc
GeoPackage_Vector_Jupiter	GeoEdgePlugfest-S2-GeoPackageVector-sourceName-orgName.doc
[GeoPackage_Vector_Rigel]	GeoEdgePlugfest-S2-GeoPackageVector-sourceName-orgName.doc
GeoPackage_Vector_Orion	GeoEdgePlugfest-S2-GeoPackageVector-sourceName-orgName.doc

Source type & Source short name	Template to provide feedback
GeoPackage-Raster_Apollo	GeoEdgePlugfest-S2-GeoPackageRaster-sourceName-orgName.doc
GeoPackage-Raster_Jupiter	GeoEdgePlugfest-S2-GeoPackageRaster-sourceName-orgName.doc
GeoPackage-Raster_Orion	GeoEdgePlugfest-S2-GeoPackageRaster-sourceName-orgName.doc
WMS_Mercury	GeoEdgePlugfest-S2-WMS-sourceName-orgName.doc
WMS_Mars	GeoEdgePlugfest-S2-WMS-sourceName-orgName.doc
WMTS_Pluto	GeoEdgePlugfest-S2-WMTS-sourceName-orgName.doc
[WMTS_Calypso]	GeoEdgePlugfest-S2-WMTS-sourceName-orgName.doc
WMTS_Oberon	GeoEdgePlugfest-S2-WMTS-sourceName-orgName.doc
WFS_Janus	GeoEdgePlugfest-S2-WFS-sourceName-orgName.doc
WFS_Neptune	GeoEdgePlugfest-S2-WFS-sourceName-orgName.doc

4.7.3. Communications

If there were any issues with a test, the questions were logged to the issue tracker. Participants were encouraged to watch the repository during the sprint so they were notified and able to provide comments if a question from another participant came up.

4.8. Templates

Each user (client) had to test a data or server and then answer a set of questions. The questions for the vector and raster sources are summarized in this section.

4.8.1. Vector questions

Inland water body query

Find all inland water bodies where the full name starts with 'Lago’ and the highest elevation is greater than 70.

Reservoir query

Find all inland water bodies where the inland water type is reservoir and the area is greater than 0.046.

Trail Number query

Provide the full names of all trails that have specified domain value attribute containing the string subset: TraillNumber:T300.

Linear Rivers query

Find all linear rivers where the full name ends with 'de la Plata'.

Guaynabo query

Find all built up areas where the height is less than 35, the memorandum is ‘San Juan’, and the World Port Index Identifier is 'Guaynabo'.

Firefighting Carretera query

Find all buildings where the address does not contain Carretera, the feature function is firefighting, and the specified domain value starts with '(Zipcode:006'.

S1200 query

Find all roads where the geography name is 'Pr- 20', and where the feature unique identifier is S1200.

Conservation area query

Find the largest conservation area based on area and report the full name of that conservation area. What is the full name? What is the Area? Provide a screenshot.

ICAO query

Find the ICAO Location Indicator for the heliport located at the Bayamon Rgnl Hospital. What is the location indicator? Provide a screenshot.

Subdivision query

Find the administrative subdivision that contains the building “Cuerpo de Bomberos de Orocovis”. What is the name? Provide a screenshot?

4.8.2. Raster questions

Provide screenshot for the zooms (and scales) specified.

Note: In the below requests, the center point of a designated area is identified. The participant should go to the center point and then zoom to the designated scale and take a screen capture of the resulting image. The screen capture should be bigger (contain) than the image returned to ensure that we will be able to compare images returned by different clients.

Zoom to full extent of the layer

Scale: 1:500,000

The extent of the image returned should be centered on the centroid of Puerto Rico, which is approximately this location: EPSG 4326: - 66.66, 18.20 and then zoom to the 1:500,000 scale. If the designated scale is not available, zoom to the closest scale that is available and include that information along with the image.

Scale: 1:20,000

The extent of the image returned should be centered on the centroid of Puerto Rico, which is approximately this location: EPSG 4326: - 66.66, 18.20 and then zoom to the 1:20,000 scale. If the designated scale is not available, zoom to the closest scale that is available and include that information along with the image.

Chapter 5. Results and recommendations

5.1. Summary of experiments

The results of Sprint 1 were summarized in the following table.

Provider / Consumer	E	L	Z	H	G	J	F	C	B	A
GeoPackage_Vector										
Apollo	X	X	X		X	X	X			
Jupiter	X	X	X		X					
Rigel	X	X			X					
Orion	X	X	X		X					
								X		
GeoPackage-Raster										
Apollo		X	X		X		X		X	X
Jupiter		X	X		X				X	X
Orion		X	X		X	X			X	X
								X	X	X
									X	X
WMS										
Mercury		X	X	X	X					X
Mars			X	X	X					X
										X
WMTS										
Pluto			X	X	X		X			
Calypso			X	X	X		X			
Oberon			X	X	X		X			
WFS										
Janus		X			X	X				
Neptune		X			X	X				

Figure 1. Results Sprint 1

The first row provides the label used to identify each client in an anonymized way. For example: Client E, Client L, etc. In total ten clients were used in the Plugfest.

The first column identifies the sources of data and servers. The contributions were also anonymized. They were sorted in the table by the type of contribution. For example, the Plugfest had 3 WMTS servers: Pluto, Calypso and Oberon.

The red marks indicate that the client was not able to interact with the server provider. Overall most servers were able to communicate with the clients.

The results for Sprint 2 are shown in the Sprint 2 Results table. Similar to the previous table, it shows if a client was able to interact with the server provider. In addition, it was also captured by shading the cells green if the client was able to successfully perform all the tests with a particular source.

Provider / Consumer	E	L	Z	H	G	J	F	C	B	A
GeoPackage_Vector										
Apollo	X	X	X		X		X			
Jupiter	X	X	X		X		X			
Orion	X		X		X		X			
GeoPackage-Raster										
Apollo	X	X	X		X		X		X	X
Jupiter	X		X		X		X		X	X
Orion	X				X		X		X	X
Astra										X
A_7_13									X	X
A_12_12									X	X
A_14_14									X	X
WMS										
Mercury	X	X	X	X	X		X			X
Mars	X		X	X	X		X			X
WMTS										
Pluto	X	X	X	X	X		X			
Calypso					X					
Oberon	X	X	X	X	X					
WFS										
Janus	X	X		X	X					
Neptune	X	X		X	X					

Figure 2. Sprint 2 Results

5.2. Selected screenshots

In the following figures are some examples provided by the participants:

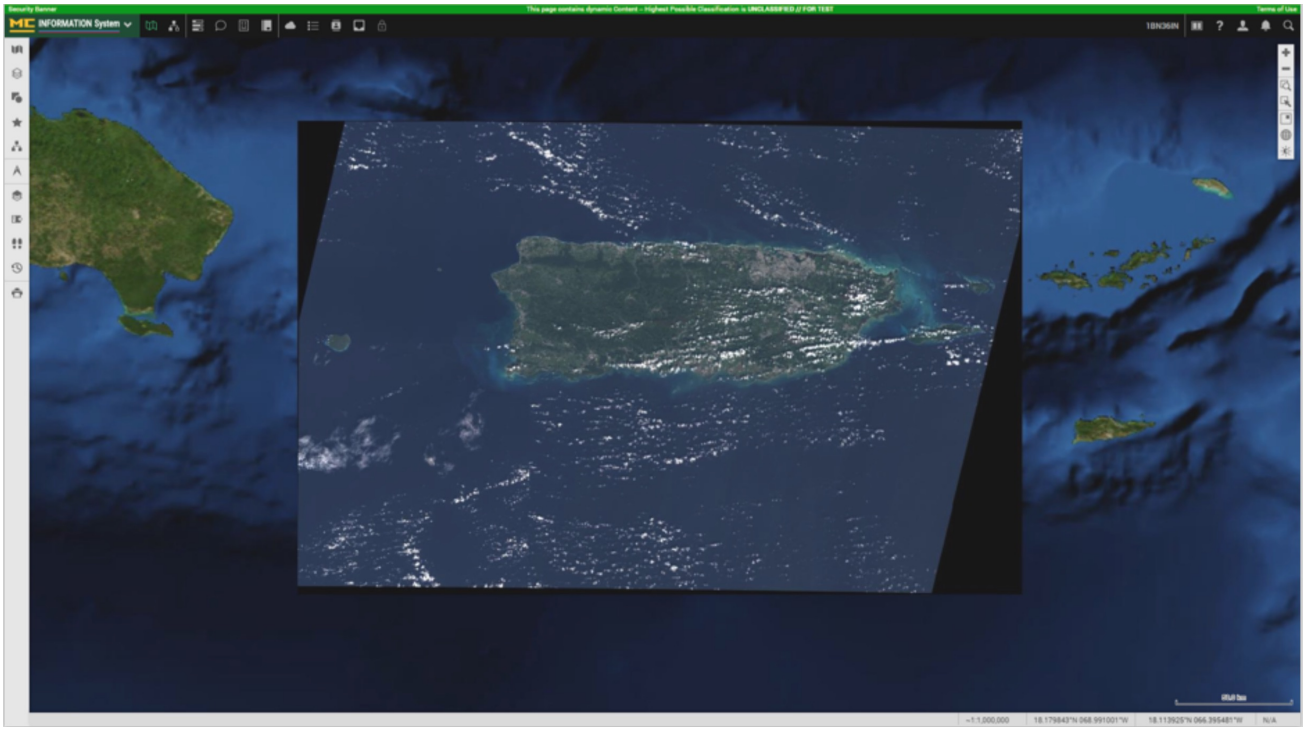

Figure 3. Full extent raster data from GeoPackage with Client A and GeoPackage Vector Apollo

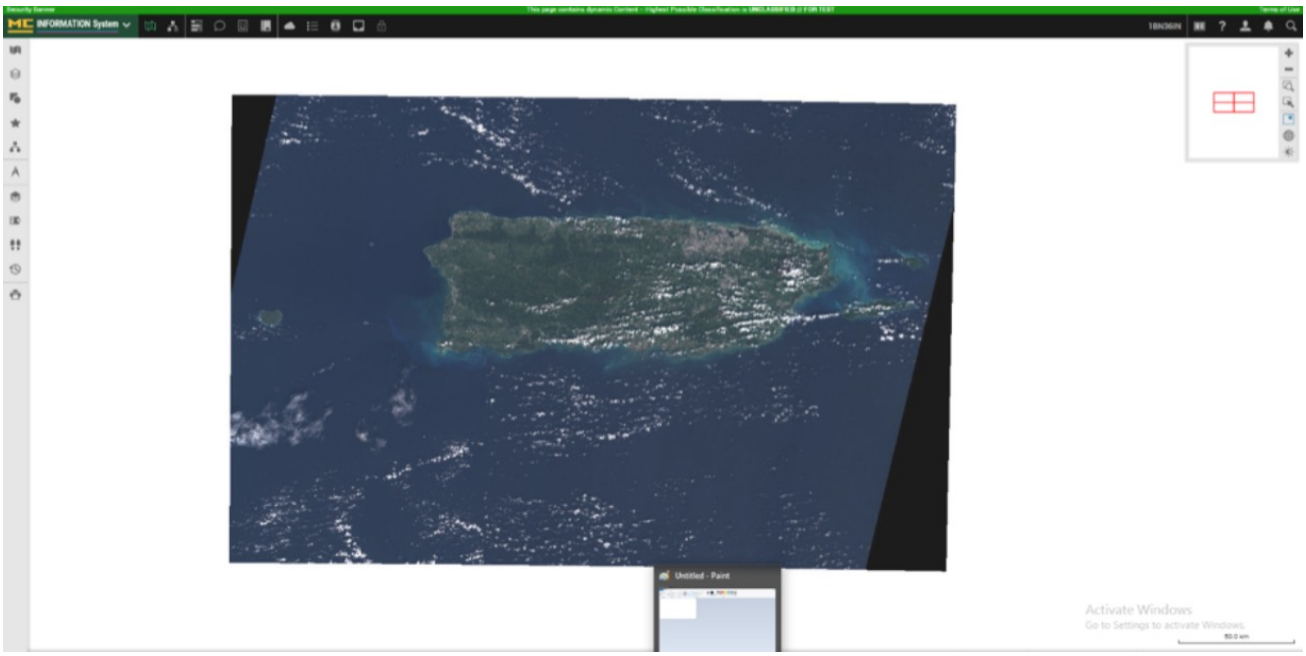

Figure 4. Full extent raster data from WMS with Client A and WMS Mercury

Figure 5. Full extent raster data from WMS with Client L and WMS Mercury

Figure 6. 1:25000 extent raster data from WMS with Client H and WMS Mercury

Figure 7. ~1:25000 extent raster data from WMS with Client G and WMS Mercury

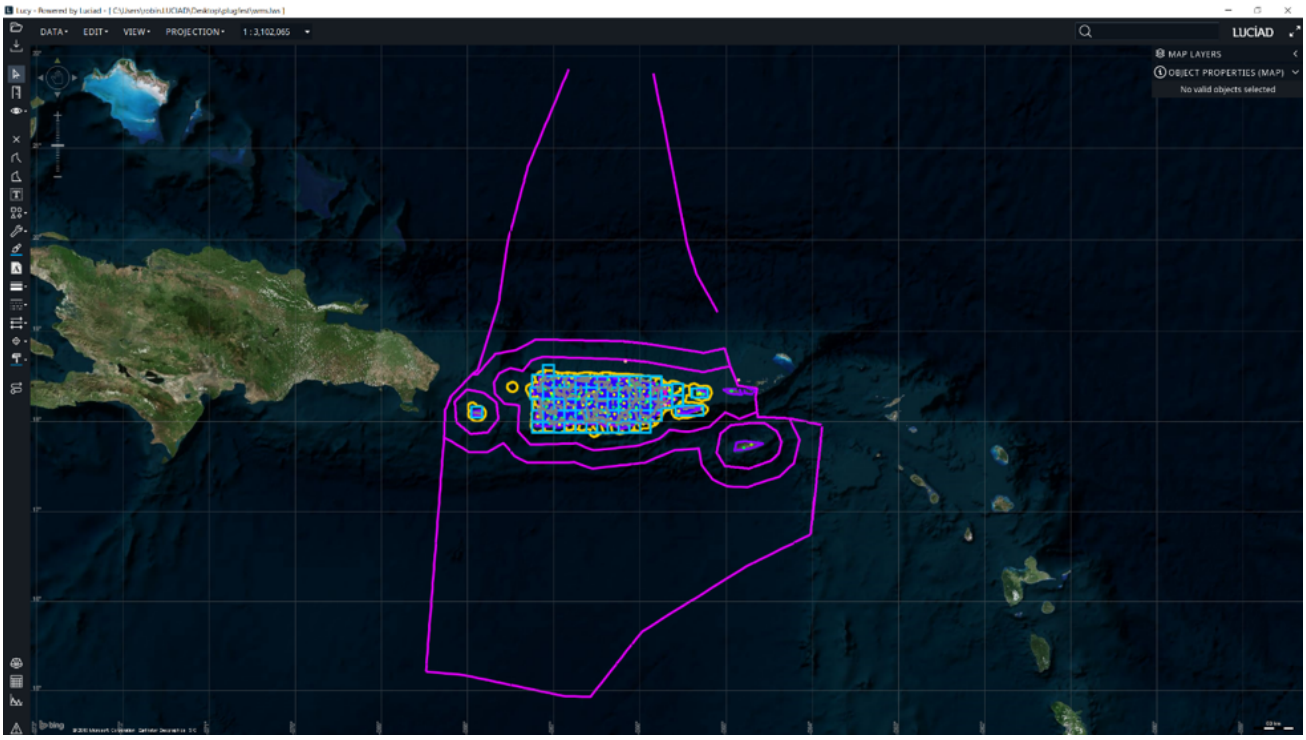

Figure 8. Vector and Raster data from WMS Mars by Client G

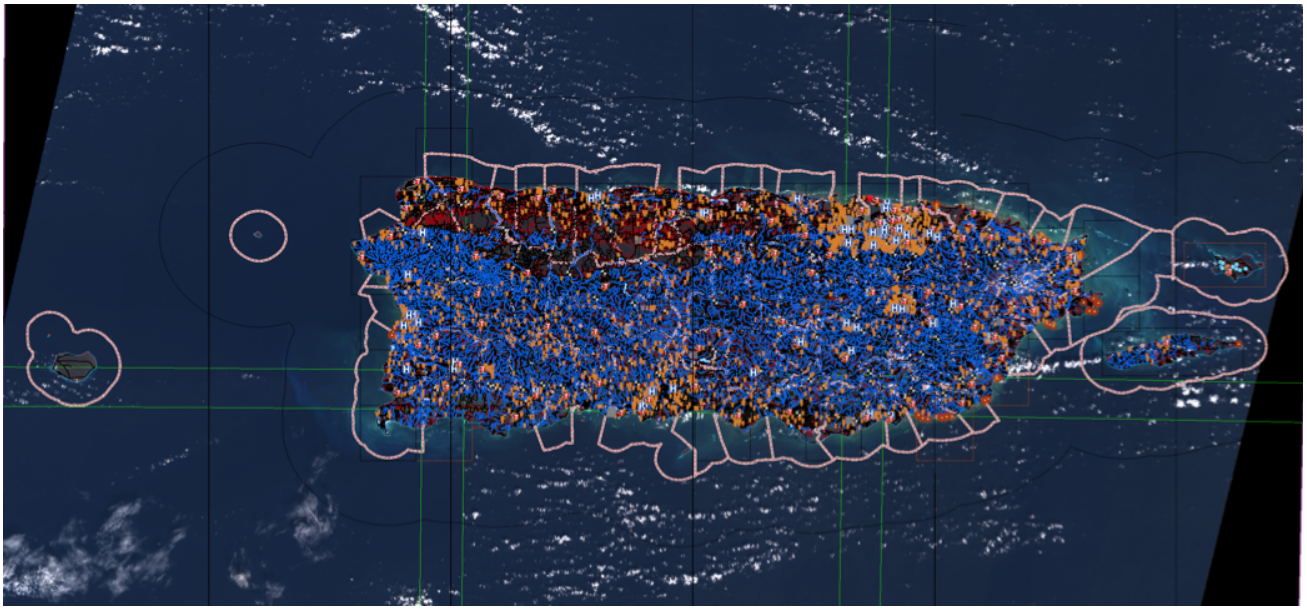

Figure 9. Client showing both GeoPackage vector and raster data

5.3. WMS

5.3.1. Use both name and title for naming layers

A server didn't use the <Name> element to name the layer. Clients were not able to do GetMap request. The WMS 1.3 Specification states the role of <Title> and <Name>:

```
7.2.4.2 Names and titles
A number of elements have both a <Name> and a <Title>. The Name is a text
string used for machine-to-machine communication while the Title is for the
benefit of humans. For example, a dataset might have the descriptive Title
“Maximum Atmospheric Temperature” and be requested using the abbreviated Name
“ATMAX”.
```

Related issues:

- #34 - Client H for WMS Mars came in blank
- #38 - Client H can't open WMS Mars
- #75 - Can't open WMS Mars

5.4. WFS

5.4.1. Axis order

Data providers should treat properly urn:ogc:def:crs:epsg::4326. The axis order is Latitude Longitude. This can happen in the following situations:

1. When performing an HTTP request
2. When returning data about a feature

The snippet code bellow shows an incorrect axis order for Puerto Rico.

Example Incorrect XML Return

```
<gml:MultiSurface     gml:id="INLAND_WATERBODY_S.5.pl" srsName=
"urn:ogc:def:crs:EPSG::4326" srsDimension="3"> <gml:surfaceMember>
<gml:Polygon gml:id="INLAND_WATERBODY_S.5.pl.0" srsName=
"urn:ogc:def:crs:EPSG::4326" srsDimension="3"> <gml:exterior>
<gml:LinearRing> <gml:posList>
  -66.57471640699998 18.36690177100007 0
  -66.57475487399995 18.36692017100006 0
  -66.57479807399994 18.36692930400005 0
  -66.57483167399994 18.36693850400007 0
  -66.57488447399999 18.36694770400004 0
  -66.57494700699993 18.36696597100007 0
```

Related issue: #15 - Incorrect axis order interpretation for urn:ogc:def:crs:epsg::4326 in WFS Janus

5.4.2. Query issues

Some queries seem difficult to execute. Several clients reported that Query 10 can't be executed:

```
Query 10: Find the administrative subdivision that contains the building
“Cuerpo de Bomberos de Orocovis”
```

The process might involve a 2 step process:

1. Select the layer
2. Run a query inside that layer: select * from BUILDING_P WHERE ZI005_FNA="Cuerpo de Bomberos de Orocovis";

```
select * from BUILDING_P WHERE ZI005_FNA="Cuerpo de Bomberos de Orocovis";
```

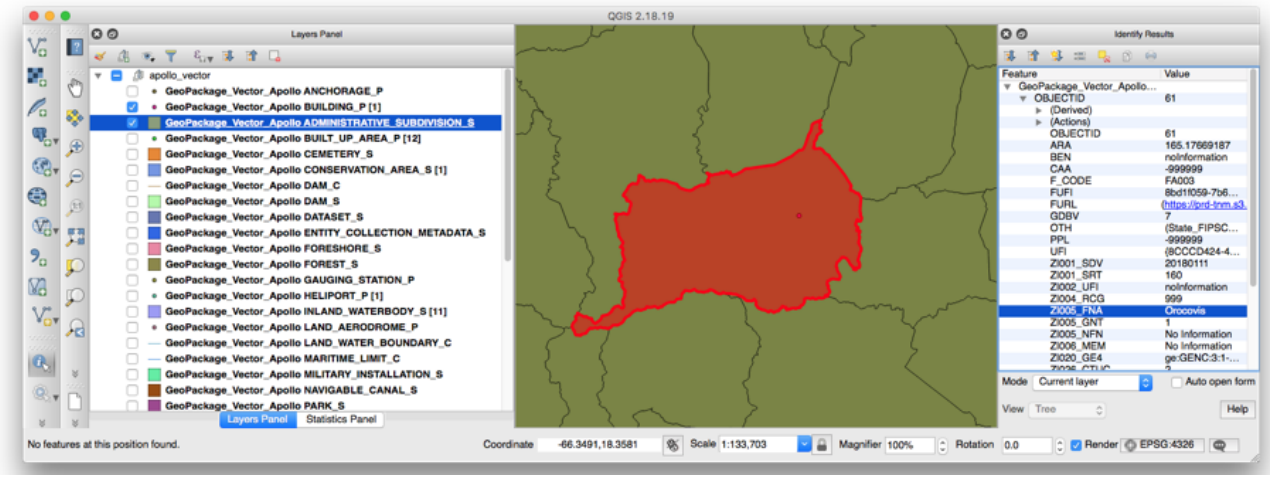

Figure 10. Query 10 Client View

Similarly it was reported that it was only possible to query one layer per request (Issue 52).

A thin client didn't support attribute querying (Issue 85).

Related issues:

- #52 - Only one layer per request
- #85 - Client H - visual queries for WFS
- #88 - Couldn't execute Query 10 - contains

5.4.3. Interacting with different versions WFS

Some servers support multiple version of WFS. This server capability enables clients to get the data using the preferred version of a WFS.

5.5. WMTS recommendations

5.5.1. Validate GetCapabilities document

Service providers should verify that the GetCapabilities document validates against the XML Schema.

Related issue: #67 - The GetCapabilities response from the Pluto WMTS is not valid against the WMTS XML Schema

5.6. GeoPackage results

5.6.1. Raster and vector data in one file

The GeoPackage standard and NSG profile permit a user to include both raster and vector data in the same file. One provider combined the GGDM vector data with a patch of imagery at a higher resolution than the supplied Sentinel 2A data and also added an elevation raster dataset. Although their demo exceeded the scope of the prescribed tests, it highlighted the potential for doing useful raster/vector mashups within NSG profile guidelines. This screenshot shows the edge of the imagery patch overlaid on a public basemap.

Figure 11. GeoPackage with both vector and raster data

5.6.2. Sort attributes in the SQLite schema

When users are interacting with clients and users are not experts in the data, it might be useful that the schema is presented in a more useful way. Sorting attributes alphabetically in the SQLite schema will allow to easier find attributes in user interfaces when selecting features to filter.

Related issues:

- #21 - Fields did not populate in sequential/alphabetical order

5.6.3. Remove local links

If GeoPackage files contain links to data producer local file system, some data (e.g styles) might not be accessible. In the testing, at least one client saw significant slowing in the opening and displaying of the data because of these links.

A client reported:

```
Selecting all layers caused QGIS 2.18 to show pinwheel of death for 15
minutes. Data loaded when selected only the 9 feature tables included in the
test, excluding other feature tables and all style and attribute tables.

Since test does not require styled features it might be useful to omit style
tables from schema, as they account for most of its size and complexity.
```

Related issues:

- #22 - Bigger files load slower
- #71 - Remove local links from GeoPackage file

5.6.4. Investigate further GDAL validation issues

Several GDAL validation issues were reported that require further investigation with GDAL developers:

Related issues:

- #69 - GDAL Validation of GeoPackage file - Wrong default for definition of gpkg_spatial_ref_sys
- # 70 - GDAL Validation - Unexpected data types
- #72 - GDAL Validation - Inconsistent values in matrices
- #73 - GDAL Validation - Req 93: Wrong default for metadata of gpkg_metadata

5.6.5. Investigate further GeoPackage performance

Some files >600 MB were slower to load. Need to investigate further the raw causes of such behavior.

Two files in Sprint 1 with raster data were 1 GB and 5 GB. Raster queries were easy to perform.

Related issue: #22 - Bigger files load slower

5.6.6. Investigate further transparency

Some clients reported apparent transparency in raster layers.

Related issue: #82 - Apparent transparency on raster layer in Client Z with GeoPackage Raster Apollo

5.6.7. Mashups containing raster elevation data

All the clients were able to open the file containing both raster and vector data. The GeoPackage contained high resolution images and elevation data in the 2D gridded coverage extension schema. Tile-based, pyramidal, floating-point raster data is a distinguishing feature of GeoPackage.

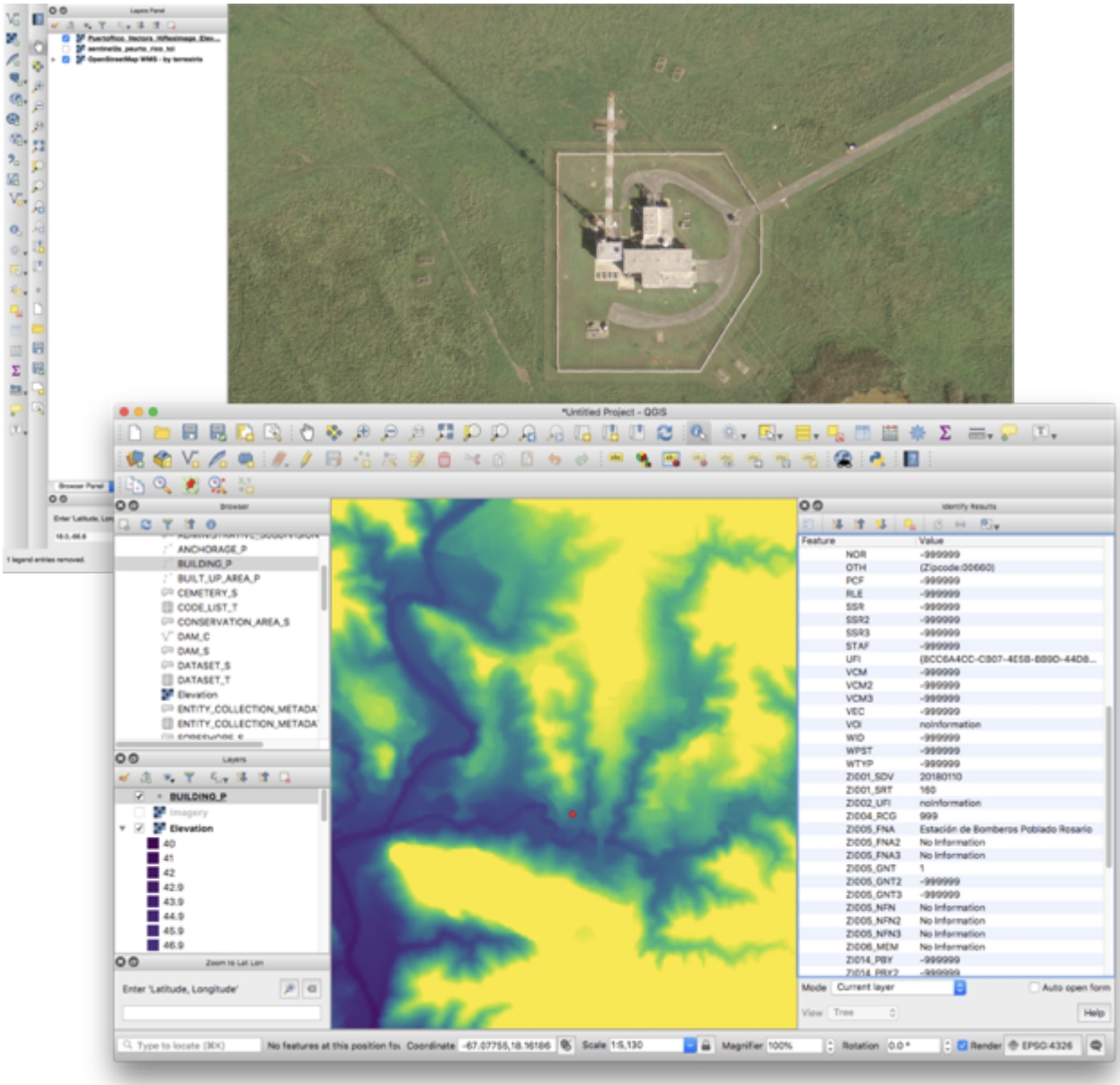

Figure 12. GeoPackage with high resolution and elevation data

Chapter 6. Test suites issues and releases

The test results of Plugfest identified several bugs or shortcomings in the test suites. This section provides a summary of the releases of updated test suites and issues reported as part of this initiative.

6.1. Summary of releases related to the Plugfest

- GeoPackage 1.2 NSG test suite
  - Release 0.5 (2018-08-28)
    - #21: Test NSG_filenameExtension is a duplicate of the test * filenameExtension
    - #36: Lack of metadata results in SQLITE ERROR hard failure
    - #38: Fortify scan reports issues
    - #37: Geopackage having no Tile data results in SQLITE ERROR
    - #27: Improve exception message of test * dataValidity_gpkg_spatial_ref_sys
    - #30: Test metadataSchemaValidation fails if table gpkg_metadata contains multiple values with at least one not NMIS valid entry
    - #42: Introduce Dockerfile and Maven Docker plugin
  - Release 0.4 (2018-07-13)
    - #33: Set GeoPackage 1.2 ETS dependency to version 0.7
    - #28: Remove duplicated test inherited from ets-gpkg12
    - #10: No Such Function: ST_MinX
    - #22: Test “dataValidity_gpkg_tile_matrix” fails if gpkg_tile_matrix contains zoom levels which are not present in data
    - #12: N S G_CRSdefinitions Test - java.lang.NoClassDefFoundError: org/geotools/util/UnsupportedImplementationException
    - #18: Clean up ETS
- GeoPackage 1.2 test suite
  - Release 0.7 (2018-07-13)
    - Fix #76: Several tests are executed multiple times
    - Fix #64: Failure due to space in filename
    - Merge #73: R146 147
    - Fix #51: Review test requiredSRSReferences
    - Fix #60: The spatial issue revisited

        - Merge #69: Adding two samples
        - Merge #65: Adding a test case with a file with a space in it

6.2. Issues and Pull Requests of Executable Test Suites and Specifications

- GeoPackage Specification
    - Requirement 32/Req 32 Test Clarification Needed
    - Requirement 13 Information Incomplete / Test Incomplete
    - Test needed for feature instance geometry within feature extents
    - Requirement 78 removed but needs to be restated and included
    - Req 78 equality expectation
    - Req 67 and extensions
    - Terminology in specification GEOMCOLLECTION
- Naming conventions for tables, columns
- GeoPackage 1.2 Test Suite
    - Pull Request - Feature tests handling almost all of the geometry blob information
    - Pull Request - Corrections in support of passing Fortify tests
    - RTreeIndex Tests Failure
    - The spatial issue revisited
    - Performance when visiting all feature instances
    - Failure due to space in filename
    - Testing of large files takes a long time
    - No requirement can be found for test "feature S R Sconsistency"
    - Fortify Scan Issues
- GeoPackage 1.2 NSG Test Suite
    - Pull Request - Remove NSG 19B Features Extents Tests and Other Issues
    - Pull Request - Issue #38: Corrects fortify scan issues; Issue #36 and #37 Table Presence check before test
    - No Such Function: ST_MinX
    - Improve exception message of test dataValidity_gpkg_spatial_ref_sys
    - Remove duplicated test inherited from ets-gpkg12
    - Test metadataSchemaValidation fails if table gpkg_metadata contains multiple values

with at least one not NMIS valid entry
    - Test dataValidity_gpkg_contents fails with "ResultSet closed"
    - CRS Tests done via string comparison
    - CRSdefinitions test fails due to dependency issue
    - Lack of metadata results in SQLITE ERROR hard failure
    - Geopackage having no Tile data results in SQLITE ERROR
    - Fortify scan reports issues
- WMS 1.3 NSG Test Suite
    - Integrate execution of ETS WMS 1.3
    - Tests "wms Get Feature Info Feature Count With Value Of One/Ten" cannot handle non GML responses
- WMTS 1.0 NSG Test Suite
    - Test GetTileParametersKvp.wmtsGetTileRequestFormatParameters fails cause the RESTful URL is used
- WFS 2.0 (NSG) Test Suite
    - Locking tests are executed altthougth locking is not supported
    - Test intersectsCurve fails with TopologyException
- DGIWG Core test Suite
    - Dependency Issue
- TEAM Engine
    - Config.xml required, not present, and not built

Chapter 7. Applications and strategies from implementers

This section provides direct feedback and recommendations from implementers about how to use their tools to interact with NSG profiles data and services.

7.1. FME

Vector queries in the FME Client can be performed two ways:

1 - Interactively using FME Data Inspector as the client alone.

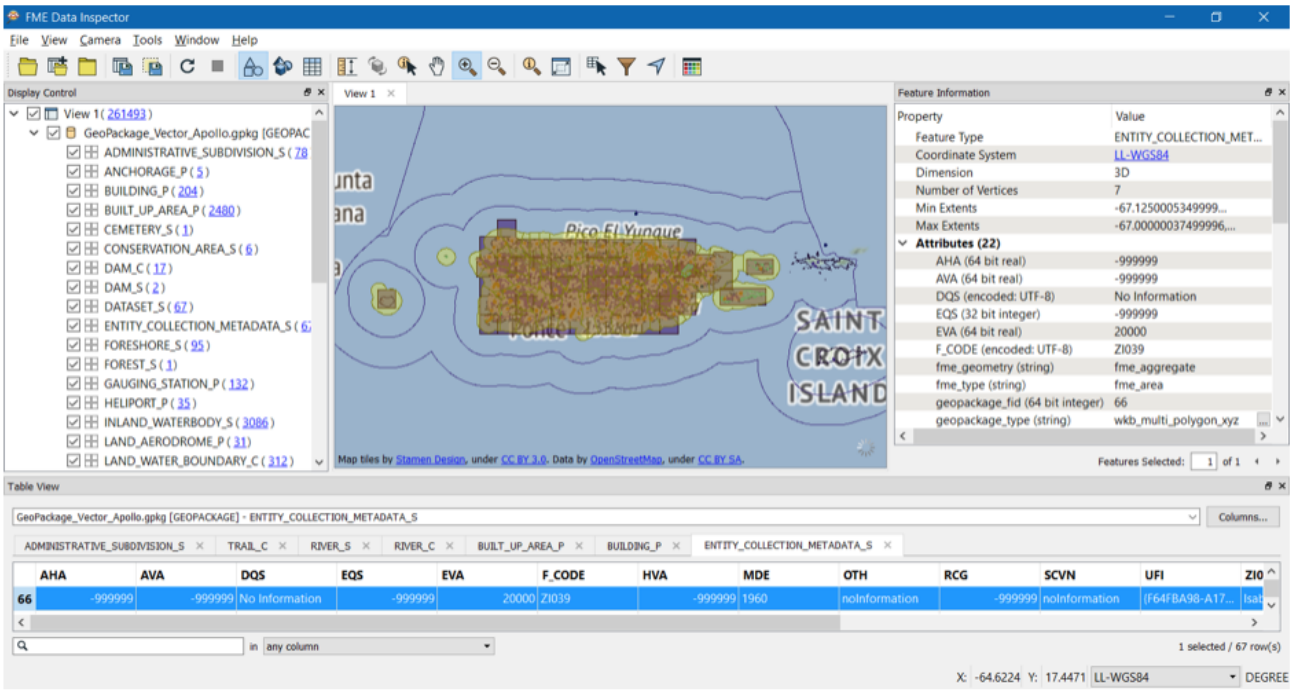

Figure 13. FME Client

2 - Using the FME Workbench with a workspace script to automate the process.

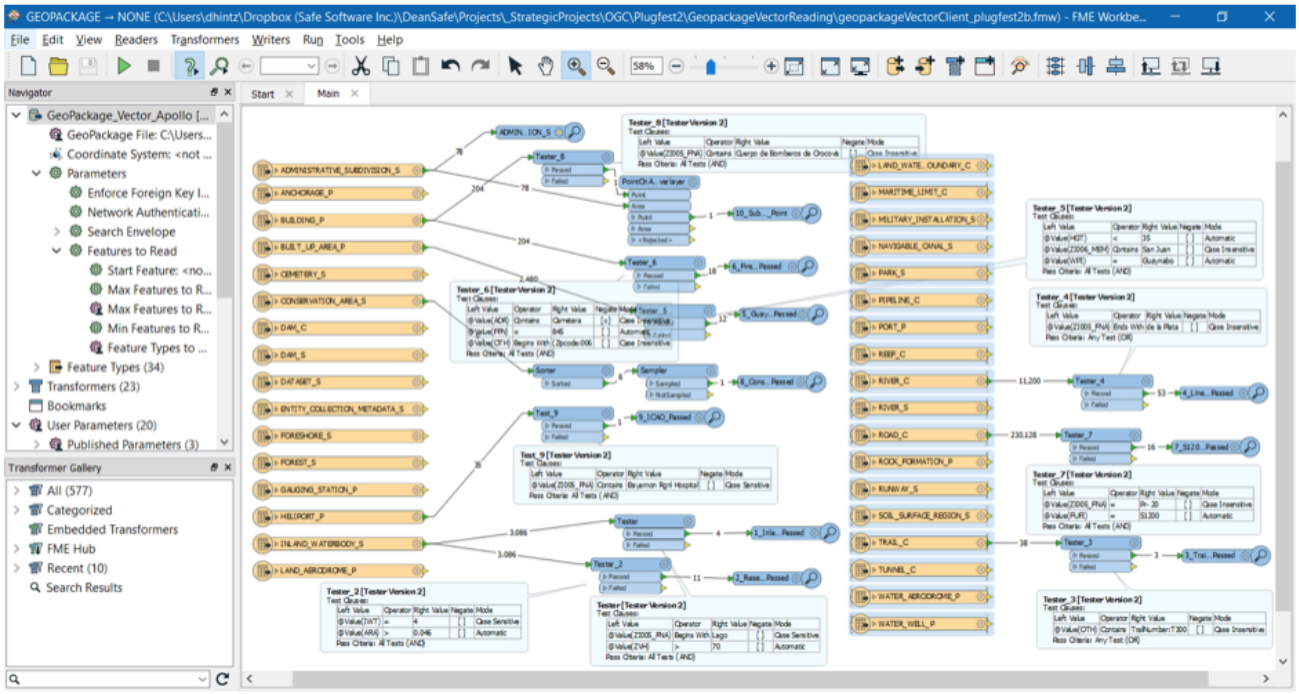

Figure 14. FME Workbench

When FME is used to read a GeoPackage raster tile dataset, the Data Inspector client optimizes the display by balancing the displayed resolution with the zoom level. Unless a specific zoom level is chosen, FME automatically chooses the highest resolution zoom level that can be displayed at the extents chosen, and then resamples as needed.

7.2. Esri

ArcGIS Desktop was used to Create Mosaic Dataset (Data Management Tools) and to add the images into the dataset. When adding the images the default parameters were kept including the calculation of raster statistics. With the calculation of the statistics the mosaics remain interactive and available to further analysis.

ArcGIS Desktop was used for publishing the Map Services with allows for the creation of 1-22 zoom levels. The default values were kept for all services.

For the creation of the GeoPackages, Esri turn to the Data Interoperability Tool as opposed to the Add Raster To GeoPackage (Conversion Tool). Work is in progress to make the creation of GeoPackage files more straight forward, in particular, in ArcGIS Pro.

Esri built the queries into the JavaScript and .NET apps, which is easy to use by non-experts. In ArcGIS Pro, the SQL statements were copied and referred back to them for each data source. Nothing special was done to speed up the return of the requests.

Esri stated that setting up the raster and vector GeoPackages, the WMS, WMTS, and WFS was fairly straight forward. Feedback was provided related to test engine irregularities. Esri achieved the goal to reduce the number of errors found in the NSG profiles.

7.3. GeoSolutions

During this experiment two services where provided: WFS and WMTS, both based on the correspondent NSG profiles. The two services were made available with a single GeoServer instance and the necessary GeoServer NSG extensions and plugins, providing a different end-point for each service, i.e. WFS and WMTS.

The provided vector and raster data was also configured in the server. Vector data was stored in a PostgreSQL database in the server. The database schema was adapted to support the NSG versioning needs. Auxiliary world files (.wld) where created for the raster data and directly stored on the file system and served through image mosaic GeoServer extension. Clients tests feedback and the follow up was done with the support of GitHub issues. The provided WFS and WMTS services where respectively tagged as WFS_NEPTUNE and WMTS_CALYPSO. A total of six issues where reported for the WFS service and three issues for the WMTS service (in both sprints).

The raster data was published using GeoServer image mosaic extension, which allows the user to publish a mosaic from a number of georeferenced rasters. An auxiliary world file (.wld) was created for each granule, and then an image mosaic datastore pointing to the granules directory was created in GeoServer.

The already available image overviews were used as is, image mosaic takes care of matching the correct overview with the requested zoom level.

Tool ogr2ogr was used to insert the provided vector data into the PostgreSQL database and gdalinfo was used to get the necessary information to complete the auxiliary world files (.wld) content for each granule.

The raster files were already optimized, e.g. tiled, compressed and with overviews (zoom levels). For vector data, an index was created for each primary key column of each dataset.

When configuring the tile matrix sets for a certain layer, special care should be taken to select only tile matrix sets that make sense for the layer. By default all the tile matrix sets defined by the WMTS NSG profile were available.

Chapter 8. Initiative Feedback

8.1. GeoSolutions

In a distributed initiative like this one, the ability to provide the necessary feedback, in a concise and straightforward way, and make the discussion happen between all the interested parts is fundamental. It is also important to be able to keep track of what happened and be able to get a quick status overview, e.g. show me all the issues related with WFS.

GitHub issues was a good choice for this. The simple UI (not simpler) make GitHub issues easy to use by both technical and non-technical people. The labels mechanism provide a good way of managing the issues and the discussion mechanism (with the associated notifications mechanism) is very efficient to use. When creating an issue and assigning it to the interested persons, GitHub will take care of notifying those persons, making them aware of that issue.

In an ideal world, everyone involved with the created issue should be able to reproduce it in their own environment (debuggable environment), unfortunately this is usually not the case. People work on different environments, they don't have access to the same clients or servers, etc. This means that special care should be taken when describing an issue.

Improving the information provided in an issue will help all the interested parties better understand the issue and solve the problem. For example, when describing an issue related with an UI, a simple GIF visually showing the problem, is usually easier to interpret than a verbal description. When describing an issue involving a client invoking a server, the actual request send by the client to the server is a fundamental piece of information, or an alternative is to reproduce the issue with a client that is commonly available, like QGIS for example.

Appendix A: Revision history

Date	Editor	Release	Primary clauses modified	Descriptions
Aug 10 2018	L. Bermudez	.1	all	Initial version
Sep 6 2018	L. Bermudez	.2	all	Added section test issues, applications and initiative feedback and Plugfest description. Formatted document with better numbering.
Sep 8 2018	L. Bermudez	.3	all	Reviewed all the document, cleaned name of organizations acting as servers or clients, and added summary matrices of the sprints.
Sep 18 2018	L. Bermudez	.4	all	Incorporated comments and edits from Melissa Pham, Amy Youmans and Pull request 97-102.
Sep 20 2018	L. Bermudez	.5	all	Incorporated comments from Matt Sorenson and Annette Filer.
Sep 21 2018	L. Bermudez	.6	er.doc	Added doc number and logo.