Open Geospatial Consortium

USGS OGC® Interoperability Assessment Report

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Abstract

The USGS Interoperability assessment was conducted under the OGC Interoperability Program with the goal to better understand how USGS customers make use of OGC compliant Web services operated by USGS. For this assessment, USGS customers have been invited to share their experiences and to describe their use cases and experiences made with USGS data services and products. From those descriptions, recommendations have been derived that help USGS to better understand their user community and optimize their service offerings.

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1   Introduction

1.1   Scope

The USGS Interoperability assessment was conducted under the OGC Interoperability Program. The goal of this assessment is to better understand how USGS customers make use of OGC Web services operated by USGS. Currently, USGS data services get over 1 million hits per day. USGS data are being used by a range of communities at the state, county, city, and other levels for a variety of purposes, such as science and decision-support. The assessment was conducted under the auspices of the National Geospatial Program (NGP). The vision of the NGP is to "satisfy the needs of users by providing geospatial products and services that users incorporate into their decision-making and operational activities." To support that vision, the User Engagement (UE) team acts as the NGP technical outreach group and performs the following activities:

☐ Systematically gathers, analyzes and reports user requirements for "The National Map" (TNM) products and services from high priority communities of use

☐ Helps users exploit TNM products and services to meet their core mission requirements

☐ Develops and maintains relationships with users and sources of authoritative data sources

☐ Communicates NGP program activities and directions to the broad audience of government, commercial, academic and public professionals.

OGC helped the USGS assess whether OGC standards as implemented in USGS servers are meeting users requirements. The following main tasks were performed in this project:

☐ Compliance Testing: USGS provided 15 OGC standards based servers that were tested thoroughly for compliance. OGC enabled services tested included: OGC Web Feature Service (WFS), Web Coverage Service (WCS), and Sensor Observation Service (SOS)

☐ Development of use cases and investigation of usability with Communities of use: Communities using USGS data were invited to participate in a virtual exercise

(Webinar). In the exercise the Webinar was used to capture the use cases, tools and overall experience of communities interacting with USGS data.

☐ Developing executable test suites for OGC Catalogue (CAT) 3.0: At the time of this project the Catalog/CSW 3.0 standard was in process of approval. The test was developed for the basic conformance classes.

1.2 Document contributor contact points

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

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1.3 Future work

Future work is envisioned in the context of service testing. This project informed the OGC process, resulting in modifications to the initial CITE TEAM Engine test scripts for WFS (version 1.1). To make those tests fully independent of the data set supported by the service, further modifications are necessary.

1.4 Notice to all

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2 References

The following documents are referenced in 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.

☐ Service compliance testing report version 1 and version 2

☐ Candidate Catalog Service 3.0 – General Model (12-168r4), HTTP Protocol Binding (12-176r4), and HTTP Protocol Binding Abstract Test Suite (14-014r2)

3   Conventions

3.1   Abbreviated terms

API   Application Programming Interface

CalEOS   California Governor's Office of Emergency Services

DHS   Department of Homeland Security

DoD   US Department of Defense

EDXML   Emergency Data Exchange Language

EPA   Environmental Protection Agency

GeoMAC   Geospatial Multi-Agency Coordination

HDDS   Hazards Data Distribution System

KML   Keyhole Markup Language

LIDAR   Light detection and ranging

NED   National Elevation Dataset

NHD   National Hydrography Dataset

NHSS   Natural Hazard Support System

NIEM   National Information Exchange Model

O&M   Observation and Measurement

SOS   Sensor Observation Service

UICDS   Unified Incident Command and Decision Support

USGS   US Geological Survey

WFS   Web Feature Service

WMS   Web Map Service

WMSC   Web Map Service Context

4   Summary

USGS data services are an important resource for different communities, including organizations at the state, county, and city level. The data are used for variety of purposes, such as scientific research, planning, and decision-support. OGC assisted the USGS by running an interoperability assessment initiative with the goal of determining whether OGC standards as implemented in USGS servers were meeting users requirements. Three activities were part of this project:

- **Compliance Testing**: A total number of 15 Web services were tested using the CITE TEAM engine as well as additional manual tests. The goal was to evaluate the compliance of WFS, WCS, and SOS service instances. The current compliance test suite requires some of these services (WFS 1.0 and WFS 1.1) to serve a specific test data set. As it was not possible to load this test data set on the production level service instances, the compliance tests were adapted to work with generic services. The type and nature of the tests have been conserved. The modified tests and test results are described in chapter five. Future work is envisioned to make the changes official.

- **Developing executable test suites for CAT 3.0**: At the time of this project the OGC Catalog/CSW 3.0 candidate standard was in the approval process. A test was developed for the basic conformance class and published in GitHub. This test should serve as a baseline that can be advanced by other test developers. More details can be found in chapter six.

- **Development of use cases and investigation of usability with Communities of Use**: Over the course of three webinars, experiences and use case descriptions from six participants were recorded and assessed. This process yielded a broad range of use cases. Some organizations used the offered services "as is". Other organizations integrated data and services into their own workflows, developing complex processing chains and advertising new data sets based on data processing results.

In summary, all participants documented use cases that heavily depend on reliable services. These services are either part of independent web applications or part of complex workflows that in turn generate additional related data. In terms of data formats and corresponded service types, users require data to be served in multiple formats with different service types. As an example, a number of users reported using web-mapping services for base layers within their applications, whereas other users required the same data to be served in vector or raster formats that can be further processed within some GIS technology. The GIS tools used most often include various ESRI ArcGIS[1] products

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[1] http://www.esri.com/software/arcgis

as well as the open source tool QGIS[2]. A recurring desire was for notification services that inform users about service down times or potential changes to service configurations and setups. Chapter seven documents the webinars and key findings in more detail.

The report concludes in Chapter 8 with general recommendations that would help improve user experiences with USGS Web services.

5   Compliance Testing

5.1   Introduction

USGS data services receive over 1 million hits per day. To optimize user experiences with those services, as part of this project a testing campaign was conducted. The campaign followed the principles and applied the technologies of the OGC Compliance program (http://cite.opengeospatial.org). The OGC Compliance Program provides the resources, procedures, and policies for improving software implementations' compliance with OGC standards. The Compliance Program provides an online free testing facility, a process for certification and branding of compliant products, and coordination of a vibrant community that develops and supports test scripts.

Tests were conducted in two iterations. During both iterations, 15 OGC enabled Web services were tested using the OGC Compliance Program TEAM Engine version 4. The TEAM (Test, Evaluation, And Measurement) engine is written in Java and executes compliance tests defined in Compliance Test Language[3] (CTL). For testing, a local installation of the engine was used. Due to resource constraints, the second test series was reduced in size. Both iterations were completed with manual tests using the command line tool *curl[4]* (http://curl.haxx.se) and a local Java implementation to send HTTP GET and HTTP POST requests using Key-Value-Pair and XML encodings. The responses of both approaches have been validated using different XML Parsers (Xerces-J, Saxon-EE 9.5.0.2 and LibXML).

The tests were applied to different OGC enabled interfaces, such as WFS 1.0 and 1.1.0, SOS 1.0, and WCS 1.0 services. The existing WFS 1.1 compliance tests required uploading a specific test data set prior to testing. This approach is not practical when testing production servers that do not contain test data. Therefore, the test scripts were modified to make the tests more generic and therefore independent of the test data. This allowed better testing of basic functionality of USGS servers. Due to resource constraints all tests could not be modified. To offset these TEAM engine tests, numerous tests have

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[2] http://www.qgis.org/en/site/

[3] The TEAM engine can execute test scripts written in other languages as well, such as TestNG. In this project, CTL was used exclusively.

[4] *curl* is a command line tool for transferring data with URL. curl supports HTTP POST and HTTP GET amongst many other things.

been conducted manually, i.e. outside of TEAM engine. A potential strategy to modify the outstanding tests is described at the end of chapter 5.

5.2   Applied Modifications to Test Scripts

The WFS 1.1 test scripts are based on the assumption that a dedicated dataset has been made available at the service endpoint. If this not the case, most tests produce failure reports due to the missing data. To make the tests more generic, all DescribeFeatureType tests have been modified. Instead of sending a DescribeFeatureType request with a specific typename, the typename gets extracted from the capabilities response document and is dynamically loaded into the DescribeFeatureType operation (payload). This new behavior has been achieved by adding a GetCapabilities request prior to the DescribeFeatureType request. The GetCapabilities response is then parsed, the essential information including namespace settings extracted, stored in a temporary variable and eventually loaded into the DescribeFeatureType request. The response is again evaluated against the typename(s). This extended testing procedure required extensive modifications to the test scripts, as all aspects have to be described using XSLT commands. Those modifications make the test scripts more verbose and far more difficult to read. The new test scripts have been uploaded to GitHub to make them publicly available (https://github.com/opengeospatial/).

The same approach was used for some GetFeature operation tests. Problems arise when specific details of a feature are tested, such as its geospatial properties, as those depend on the feature itself, which can be of various types.

A number of tests used XML payloads sent via HTTP POST. Those tests scripts were not modified. Instead, custom scripts were developed and executed manually.

5.3   Services and Test Results

The following services have been tested:

- WFS/geonames:
  http://services.nationalmap.gov/arcgis/services/WFS/geonames/MapServer/WFSServer?request=GetCapabilities&service=WFS

- WFS/govunits:
  http://services.nationalmap.gov/arcgis/services/WFS/govunits/MapServer/WFSServer

- WFS/structures:
  http://services.nationalmap.gov/arcgis/services/WFS/structures/MapServer/WFSServer

- WFS/transportation:
  http://services.nationalmap.gov/arcgis/services/WFS/transportation/MapServer/WFSServer

- WFS/Geochemical and mineralogical data from soils in the conterminous United States:
  http://mrdata.usgs.gov/wfs/ds801?request=getcapabilities&service=WFS&version=1.1.0&

- WFS/National Geochemical Database (Rock):
  http://mrdata.usgs.gov/wfs/ngdbrock?request=getcapabilities&service=WFS&version=1.1.0&

- WFS/Geologic maps of US states:
  http://mrdata.usgs.gov/wfs/sgmc?request=getcapabilities&service=WFS&version=1.1.0&

- SOS/National Water Census Threddds: http://cida.usgs.gov/ngwmn_cache/sos

- SOS/National Water Census County Data:
  https://cida.usgs.gov/nwc/thredds/sos/watersmart/county_data/AWUDS.nc

- WFS/NHDPlus Catchments:
  http://cida.usgs.gov/nwc/geoserver/NHDPlusCatchments/ows?service=WFS&version=1.0.0&request=GetCapabilities

- WFS/Nationalatlas:
  http://webservices.nationalatlas.gov/arcgis/services/cgd113p010g/MapServer/WFSServer?SERVICE=WFS&VERSION=1.1.0&REQUEST=GetCapabilities

- WCS/Landcover:
  http://isse.cr.usgs.gov/ArcGIS/services/LandCover/USGS_EDC_LandCover/MapServer/WCSServer?request=GetCapabilities&service=WCS

  o Replaced by:
    http://isse.cr.usgs.gov/ArcGIS/services/LandCover/USGS_EROS_LandCover_NLCD/MapServer/WCSServer?request=GetCapabilities&service=WCS

- WCS/NED:
  http://ags.cr.usgs.gov/ArcGIS/services/NED_1/MapServer/WCSServer?request=GetCapabilities&service=WCS

  o Service is no longer supported

 ☐ WFS/USGS EROS Feature Service:
   http://ags.cr.usgs.gov/ArcGIS/services/Feature_Service/MapServer/WFSServer?request=GetCapabilities&service=WFS

 ☐ WCS/TNM_LandCover (MapServer):
   http://raster.nationalmap.gov/ArcGIS/services/TNM_LandCover/MapServer/WCSServer?request=GetCapabilities&service=WCS

   o Replaced by:
     http://raster.nationalmap.gov/ArcGIS/services/LandCover/USGS_EROS_LandCover_NLCD/MapServer/WCSServer?request=GetCapabilities&service=WCS

In terms of compliance, all tested services possessed minor to major issues. None of the services were fully OGC standards-compliant, but most of the services could readily be used by client applications. The Compliance issues appear to be combination of service implementations that are not fully standards compliant and set up issues that could be solved without modifications to the server software. A number of those issues were solved during "window" between the two test iterations. The second test iteration reported a number of compliant services. The detailed testing results are available in Annex B of this document.

5.4   Remaining Test Scripts Modification Strategy

WFS 1.1 supports several request encodings sent using different HTTP commands, i.e. key-value-pair (KVP) via HTTP GET, and KVP and XML via HTTP POST. The test scripts dynamically load externally governed XML files at runtime. The approach documented above, where data is temporarily stored in CTL variables and requests are dynamically generated and executed, makes it very difficult to adapt those XML files to specific service instances. The XML files are simply linked from within the test scripts, loaded, added to a request, but not further processed.

A strategy to allow testing of ad hoc feature types is to allow modification of those XML files with feature type specifics. For example, the feature type name ns:foo in the XML file is replaced with ns2:bar (as it is de facto supported by this service instance) and the response tested against this ns2:bar feature type name. This approach, though more a "hack" than proper testing routine, works surprisingly well for a number of tests, in particular GetFeature operation tests.

5.5   Test Suite Recommendations

Develop a Basic WFS 1.1.0 profile that will test WFS 1.1.0 servers without the need to have test data. An issue has been created in the CITE issue tracker:

https://github.com/opengeospatial/ets-wfs11/issues/1

Change test scripts to use another testing language. The CTL language is very hard to use. TestNG appears to be easier, but more information is required on the OGC web site about how to use TestNG.

TEAM Engine console reporting requires improvement to better present the failures instead of all information, which is hard to parse. Fix is in progress:

https://github.com/opengeospatial/teamengine/issues/44

6   Catalog Service 3.0 Executable Test Suite

At time of this project, Catalog Service 3.0 had just been released for Public Comment, and it was on its way to approval as a two-part standard.

http://www.opengeospatial.org/pressroom/pressreleases/2030

The two parts included a supplemental document with the Abstract Test Suite that would allow the preparation of test scripts for OGC testing environments. One of the conformance classes articulates a nominal *Opensearch* environment. There were already at least two implementations of CSW 3.0 in existence (by *CubeWerx* and *Conterra*) and a third in process (*pyCSW*). This task tackles the development of a baseline set of conformance classes.

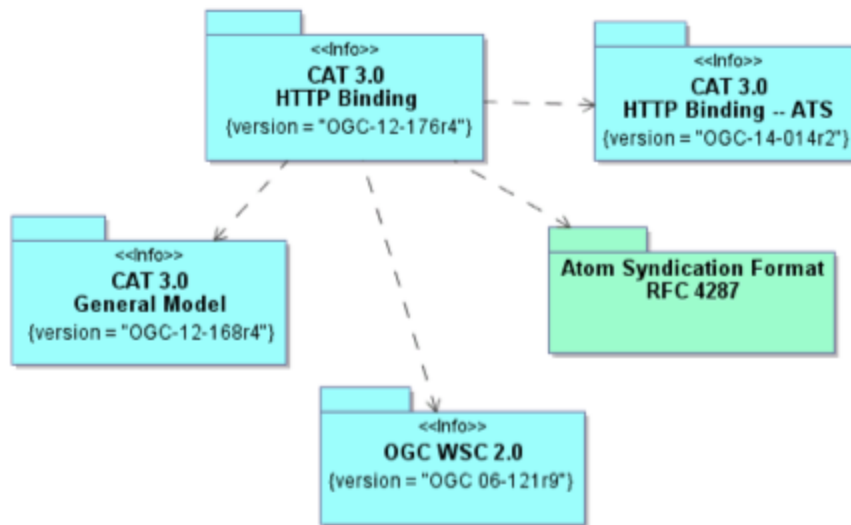The source for the development of the test was as follows:

Figure 1: Catalog dependencies

The baseline of the CAT 3.0 test suite was published in GitHub. Executable Test against getCapabilities and getRecordById were developed. Reference implementers planned to start interacting with the test September-December 2014.

https://github.com/opengeospatial/ets-cat30

7   Use Cases and Communities of Use

7.1   Call for Participation

The Call for Participation (CFP) was issued 1 May 2014. The announcement was made to all OGC members and through USGS channels by email. USGS users were invited to share their experiences and to describe their use when interacting with USGS data services and products. In total, seven responses were received in response CFP issued on May 1st (see annex A). The participants were invited to participate in 30 min Webinars, where they showed their typical workflows, demonstrated how USGS data products are used, and shared their experiences and best practices. The sessions were recorded and are available on the OGC portal. This section summarizes the main results and should help USGS to better understand their user community and to optimize their data offerings. Further, this report includes useful material for GIS client and tool developers, and documents typical problems and issues experienced by the customers. The results from this assessment were also discussed at a Webinar co-located with the OGC TC meeting in September 2014.

The following responses were received:

Organization	Topic you are interested in participating in the virtual exercise	Which Services do you use?	Software tool(s) that you are currently using to access USGS data and services
USFWS	Water Resources, Natural Resources Conversation	WFS / geonames, WFS / transportation, WFS / NHDPlus, WCS / National Elevation Dataset	QGIS, ArcGIS, GRASS, GDAL
Troup County GA Government	Data Acquisition opportunities - Lidar & imagery, cost share opportunites, consuming services	WFS / govunits, WFS / structures, WFS / transportation, WFS / Geochemical and mineralogical data from soils in the conterminous United States, WFS / National Atlas Congressional Districts of the United States, WCS / National Elevation Dataset	ArcGIS Server, & Desktop, web browser
Bay de Noc Community College	Water Resources	WFS / geonames, WFS / govunits, WFS / transportation, WFS / Geologic maps of US states, SOS / Aggregate Water Use Data System (AWUDS), WFS / National Atlas Congressional Districts of the United States, WCS / EDC Land Cover, WCS / National Elevation Dataset, WFS / Earth Resources Observation and Science (EROS) Center	ESRI ArcGIS, QGIS, web browser
Louisiana Dept. of Transportation & Development	Geological Hazards, Water Resources, Geologial Mapping, Natural Resources Conversation, Weather	WFS / geonames, WFS / govunits, WFS / structures, WFS / transportation, SOS / Aggregate Water Use Data System (AWUDS), WFS / NHDPlus, WFS / National Atlas Congressional Districts of the United States, WCS / EDC Land Cover, WCS / National Elevation Dataset, WFS / Earth Resources Observation and Science (EROS) Center	ArcGIS, web browsers, ASP/ASPX Visual Studio Apps
NGA	Service implementations with client applications	WFS / geonames, WFS / govunits, WFS / structures, WFS / transportation, WFS / Geochemical and mineralogical data from soils in the conterminous United States, WFS / National Geochemical Database: Rock, WFS / Geologic maps of US states, SOS / Center for Integrated Data Analytics, SOS / Aggregate Water Use Data System (AWUDS), WFS / NHDPlus, WFS / National Atlas Congressional Districts of the United States, WCS / EDC Land Cover, WCS / National Elevation Dataset, WFS / Earth Resources Observation and Science (EROS) Center	NGA Globe and Map of the World
California Earthquake Clearinghouse	Geological Hazards, Earthquake response	several	The California Earthquake Clearinghouse has conducted 5 exercises over the last 2 1/2 years, successfully demonstrating technology interoperabiltiy and information sharing capability, to contribute information to support immediate disaster intelligence and situational awareness. In addition to the Clearinghouse members (including USGS), our partners in this effort include Cal OES, California National Guard, FEMA R IX and NASA JPL. The Clearinghouse and our partners are using the Unified Incident Command and Decisions Support (UICDS) middleware developed by DHS to share geo-spatial and Non-geospatial information, in real time, using (but not limited to) the following applications: WebEOC, Google Earth, ArcGIS Online, Next Generation Incident Command System (NICS), SpotOnResponse mobile data collection tool, Firefox, Chrome, and Internet Explorer.
Oregon Coastal Management Program	Geological Hazards, Natural Resources Conversation	WFS / geonames, WFS / transportation, WFS / Geologic maps of US states, WFS / NHDPlus, WFS / National Atlas Congressional Districts of the United States, WCS / EDC Land Cover, WCS / National Elevation Dataset, WFS / Earth Resources Observation and Science (EROS) Center	ArcGIS, QGIS, GDAL

Figure 2: CFP Responses

7.2 California Earthquake Clearinghouse

7.2.1 Use Case

In case of an emergency, a variety of organizations have to respond to observed impacts and identified threats with resources that protect people, property, and the environment from loss. In order to coordinate the response, task resources and engage the right partners (e.g. military), critical information for decision support is required. The first response usually takes place at the local level. In case of a major disaster, observations are initially reported to the local operation center, which is equivalent to the county level. If it escalates, coordination with the regional information center is the next step. From there, other operational areas can be called in to provide mutual aid support. Depending on the disaster, coordination is further rolled up to the state/federal level.
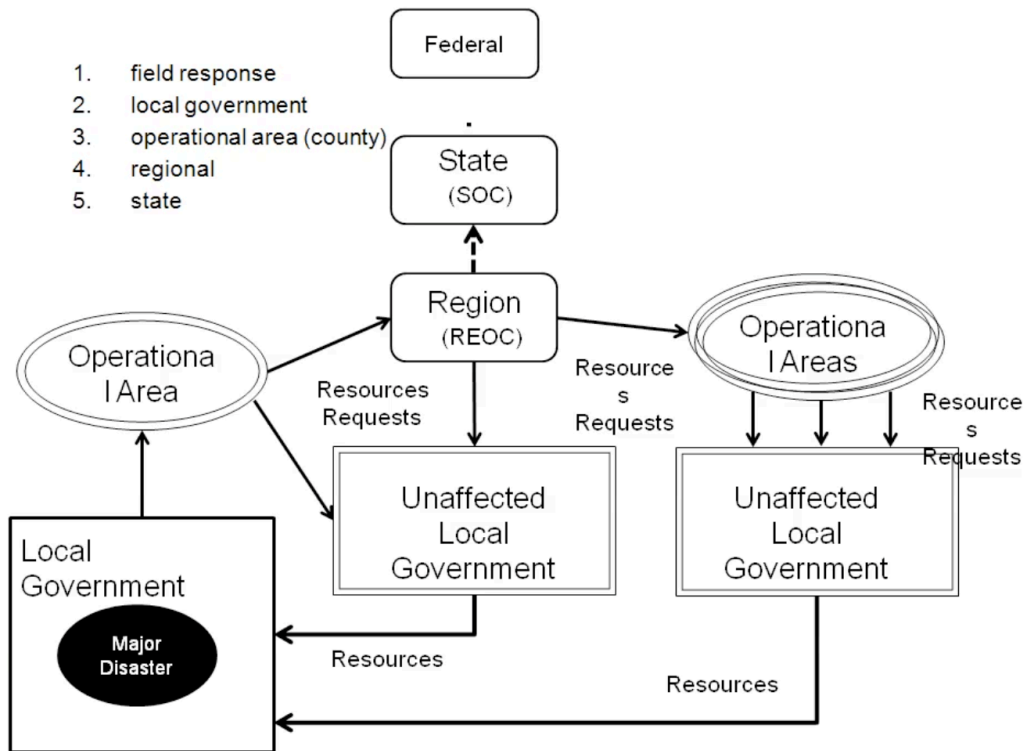

Figure 3: Local to federal communication and support chains

The state coordinates requests for resources from the local, regional, state, and federal levels through mission tasking; prioritized by life safety, property, and the environment. This coordination of an operation requires situational awareness, common operating pictures, and forecast models that forecast as yet unobserved impacts. It is important to understand what happened where with what impact, who is in charge, which information needs to be delivered to whom and how the response looks like in terms of resources employed, operating procedures, and tasks performed. The challenge is to capture and deliver authoritative information to the right level, where it needs to be managed in an

organized way. The information itself is generated at all organizational levels using a variety of technologies as well as human observers. In case of an disaster, not only does geo-referenced (GIS) data need to be integrated, but lots of other types, such as tables, reports, images, field observations, diagrams, or checklists need to be served as well. Those types cannot be easily represented in traditional GIS.

The clearinghouse started in 1971 with five managing partners, the California Geological Survey, the US Geological Survey, California Office of Emergency Services, Earthquake Engineering Research Institute, California Safety Commission. In case of an emergency, the entire range of organizations makes use of the clearinghouse, including organizations dealing with utilities, emergency responders, researchers, etc.

7.2.2 Data & Services

Data provided by the USGS is key to several partner organizations of the California Clearinghouse. The data includes aerial photography, various remote sensing data, LIDAR, several national map products, sensor networks (e.g. provided by the Department of Water Resources) or earthquake sensing devices, the Geospatial Multi-Agency Coordination platform (GeoMAC), National Hydrography Dataset (NHD), Fire and Hazard REST services from the Natural Hazard Support System (NHSS), Hazards Data Distribution System (HDDS) Explorer. The following figure represents the technology decisions taken by the California Governor's Office of Emergency Services.
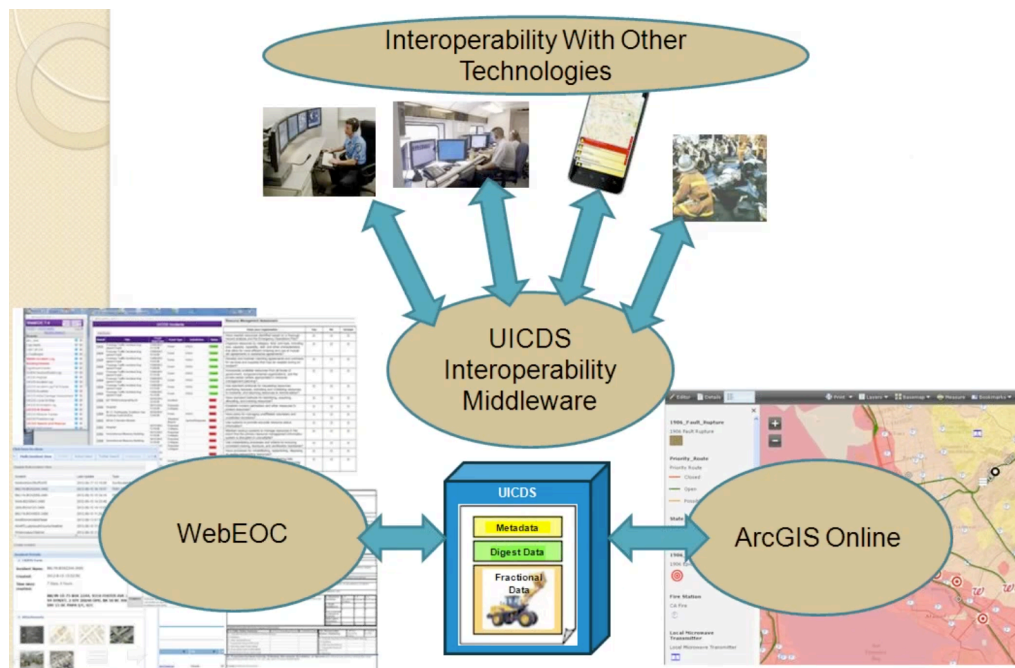

Figure 4: *CalEOS technology decisions*

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CalEOS has adaptors to a number of technologies, e.g. WebEOS, ArcGIS online, Unified Incident Command and Decision Support (UICDS), and a number of other technologies used in the field or by other organizations. The UICDS middleware plays a central role for data communication. A key challenge in the past has been to communicate and to work collaboratively on geospatial information with other agencies and organizations in the geospatial world, given that there are roughly 150-200 different interfaces (geospatial and non-geospatial) that exit in common emergency management tools and related services. UICDS represents data in a number of standard formats that come from the geospatial community, the emergency management community, or the military. Formats include OGC formats such as KML, GML, and O&M; or NIEM (which uses GML for encoding location/geographic elements). Arriving data is converted into the best fitting standard for a particular use. This approach allows the use a single platform for representing geospatial information: ArcGIS online. Putting all geospatial information on ArcGIS online has solved the problem of the high number of different interfaces and formats to a large extent, as long as the necessary software licenses can be afforded by all participating organizations.

The various text-based or report-based incident information systems used in the past have been superseded by a customized version of WebEOC, an incident management system developed by Intermedix Corp. Though WebEOC has a viewer component, it is not really a GIS tool. Therefore, geospatial information received from the various levels (local to regional to state and federal level) gets ported to ArcGIS online for efficient collaboration with external partners. This approach ensures that data is aggregated as necessary and consistently communicated across all organizations involved in the disaster management operation. Being synchronized at the state level, it is ensured that all organizations can view the same data, even though with their specific client applications that uses adapted representations.

The key role of UICDS is further illustrated in the figure 5. This figure illustrates the coordination, communication and data orchestration, between a number of organizations in an earthquake event, where there is limited time for data discovery. Incoming data needs to be analyzed and combined with other existing data, new data is produced as a result, and new maps are dynamically created with multiple layers. All these data become part of the Common Operational Data (COD), which is exchanged between systems using various UICDS middleware implementations, operated by organizations on various administrative levels. Therefore, the efficient integration of any data set into the UICDS middleware layer is critical.

The connection between the UICDS, WebEOC, and ArcGIS online allows the definition of new layers based on existing information, and enables this data to be pushed back and forth between the various systems. As an example, a layer based on a feature selection within ArcGIS online can be pushed into UICDS as a Web Map Context Layer. In the future, using OWS Context instead of Web Map Context would provide additional functionality.
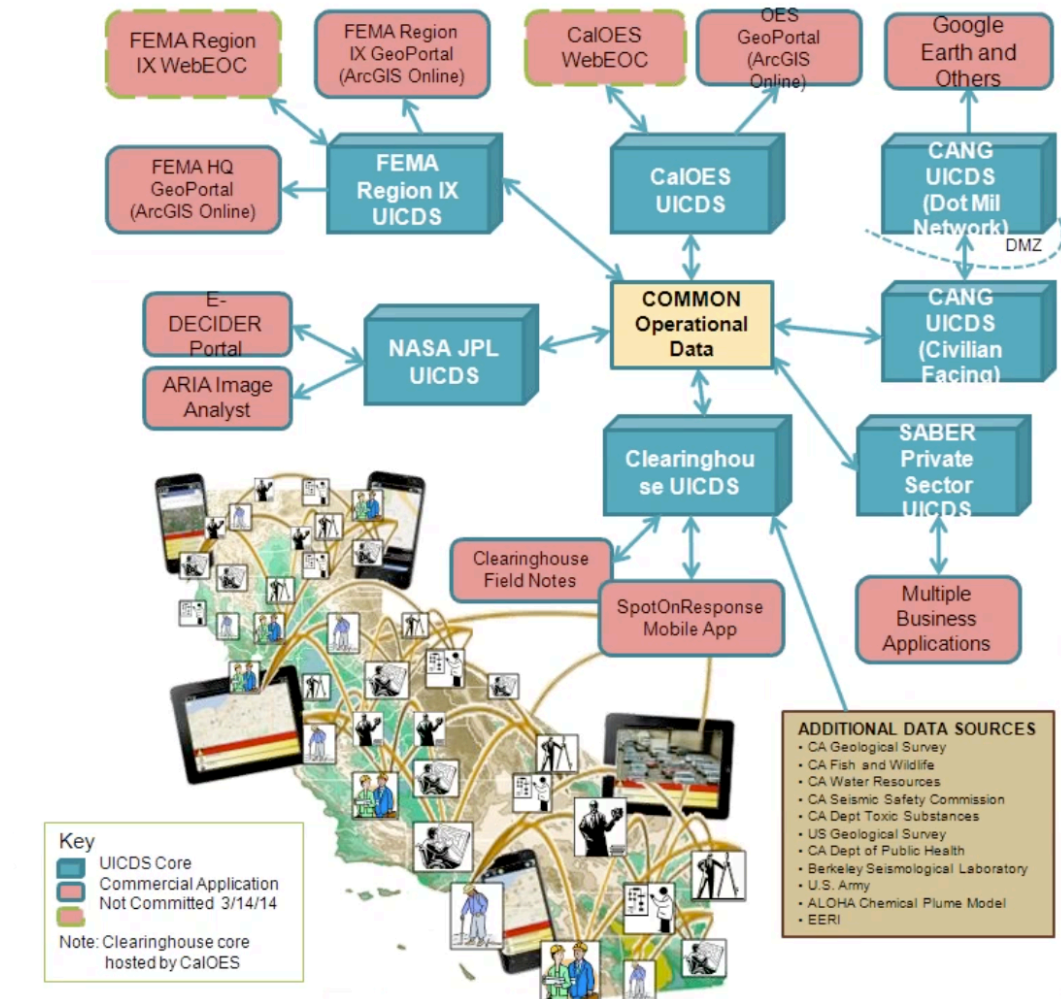
Figure 5: Technology relationships in case of disaster management operations

7.2.3 Recommendations

The following recommendations have been discussed and derived from the online meeting and use case analysis:

1. Embraced by DHS and DoD, the Unified Incident Command and Decision Support (UICDS) middleware is becoming more and more important in the domain of disaster management. Thus, by providing a direct connection into UICDS middleware from USGS services would overcome huge interoperability burdens. USGS data would become part of the Common Operational Data, i.e. data following a limited number of information models that are directly supported by UICDS. This process could be optimized by establishing a point of contact to coordinate between USGS, UICDS and OGC.

2. USGS should publish data at more than a single OGC enabled interface. Within certain communities, it might make sense to complement the data served with

other types of OGC Web services (e.g. WMS, WFS, SOS and WCS) as well as, multiple formats.

3. All USGS services should be tested for full standard compliancy to the necessary detail.

7.3   Louisiana DOTD

The Louisiana Department of Transportation and Development serves the transportation and water resource needs of Louisiana residents, businesses and government partners. Here, we discuss experiences from the GIS & emergency operations before, during, and after the hurricanes of 2005.

7.3.1   Use Case

The use case addressed preparation, analysis, and clean-up operations in the context of hurricane Katrina in 2005. Almost a decade has passed since that event, and policies and procedures have changed, following the general path towards digitalization and rapid information exchange using mobile devices (smart phones, tablets, etc.) instead of printing and distributing paper maps. Nevertheless, the principle workflows in terms of data discovery, aggregation, analysis, and produced type and content of maps remain the same, independent of changing distribution mechanisms.

One of the first maps produced (which was printed and distributed a million times in 2005) shows the different evacuation zones. This map requires detailed and up to date elevation data to calculate the different zones. Given that high resolution and quality elevation data is required in flat coastal zones, services shall be used that provide the latest and best data available. Evacuation zone maps are further detailed with evacuation routes for the different zones and phases. Evacuation information needs to be conveyed to the public well in advance to a potential flooding event. At the time of the event, real time information and continuously updated forecast information needs to be taken into account, including storm track, flooding, stream and tide gages, state of roads and highways, hospitals, people left behind, and others. As the data comes from various sources, it would be necessary to aggregate the data and make it available as service to clients in particular on mobile devices. Figure 6 illustrates an example, showing gages from USGS and the U.S. Army Corps of Engineers, combined with other information that will be served as a service by Louisiana DOTD.
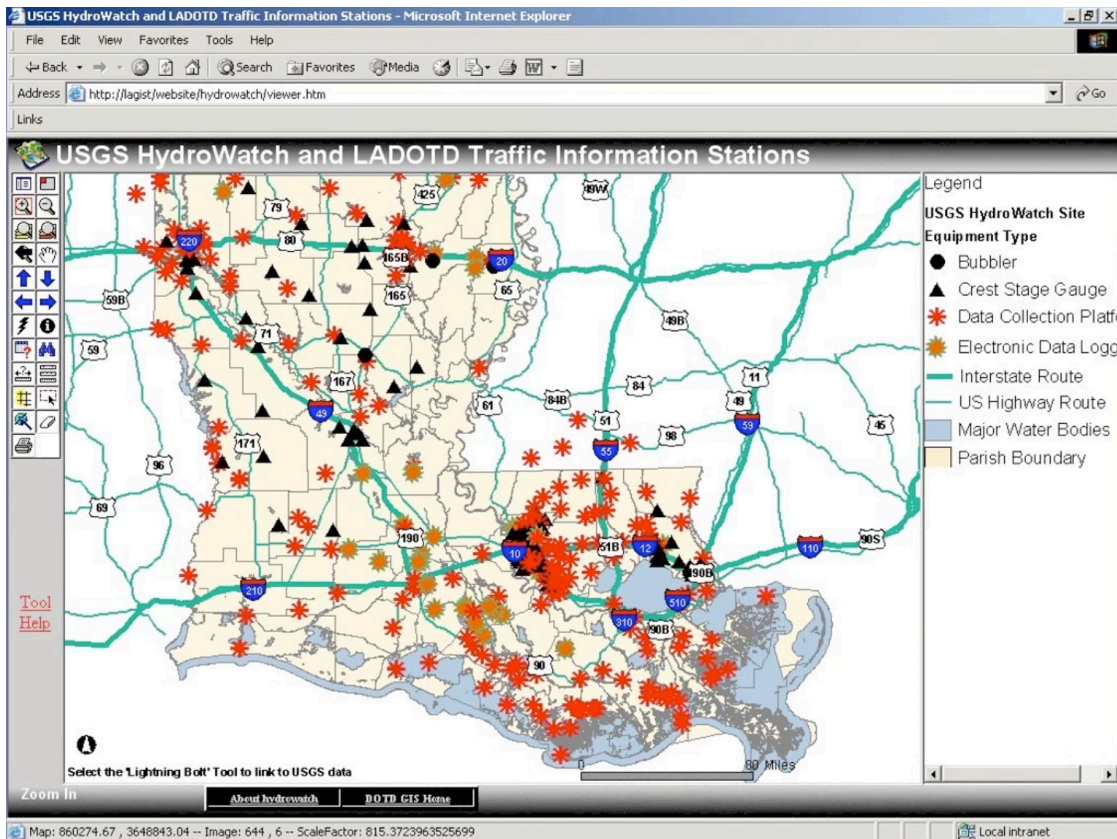
Figure 6: *Aggregated data intended to be served as a service by DOTD*

7.3.2   Data & Services

Louisiana DOTD uses specific services from USGS that are or are intended to be complemented with additional data sets, such as further hydrologic data, elevation data, weather and storm surge data, road and highway data, etc. The data services used so far include

- ☐ WFS: geonames,

- ☐ WFS: govunits,

- ☐ WFS: structures,

- ☐ WFS: transportation,

- ☐ SOS: Aggregate Water Use Data System (AWUDS),

- ☐ WFS: NHDPlus,

- ☐ WFS: National Atlas Congressional Districts of the United States,

□ WCS: EDC Land Cover,

□ WCS: National Elevation Dataset,

□ WFS: Earth Resources Observation and Science (EROS) Center

Real time data is of major interest, as data is often used to identify specific areas or serves as a basis for management operations, e.g. the number and types of pumps to dry out a flooded area or current debris removal situation. In order to process data in DOTD's GIS, data, in particular image data, needs to be transformed into vector data for further processing. This processing is not necessarily done by DOTD, but by other organizations such as FEMA or DHS, that reissue processed image data as services.

Mobile devices become more and more important in daily operations, as they allow conveying real time information from the field to the command centers.

7.3.3   Recommendations

ArcGIS Online and other ESRI client products are widely used within DOTD. Therefore, it is recommended to ensure that those ESRI products are fully compliant with OGC enabled Web services interfaces. This allows ArcGIS Online as well as other ESRI products to access USGS Web services as clients; and allows other clients to access the data when running in server mode. Only the full support of the various OGC enabled interfaces both in client and server mode offers maximum interoperability and user experience.

7.4   US Fish and Wildlife Service

7.4.1   Use Case

In this use case, we analyze the work performed by the US Fish and Wildlife Service (USFWS), ecological services division, in the context of projects related to endangered species and 404 permits, which pertain to discharge of dredged and fill material into US waterways.

The USFWS receives requests to review project proposals that are related to (possibly) endangered species conflicts and section 404 permits. *"Section 404 of the Clean Water Act establishes a program to regulate the discharge of dredge and fill material into waters of the United States, including wetlands. Activities in waters of the United States that are regulated under this program include fills for development, water resource projects (such as dams and levees), infrastructure development (such as highways and airports), and conversion of wetlands to uplands for farming and forestry. EPA and the Army Corps of Engineers (Corps) jointly administer the program. In addition, the U.S. Fish and Wildlife Service, the National Marine Fisheries Service, and State resource agencies have important advisory roles... USFWS assesses potential adverse effects*

directly encompassing wetlands and wildlife resources, conducts site visits to assess biological functionality and habitat quality, coordinates with local, state, and federal agencies, and comments to the Army Corps of Engineers" (http://www.fws.gov/charleston/404Permits.html).

The in-house part of those activities includes intensive GIS-based analysis of species, habitants, and environments. To perform this job, USFWS has various data layers available with regards to species locations and habitats at a very fine scale. Those data layers are complemented by data coming from USGS and other sources. Using QGIS and ArcGIS clients, USFWS analyzes a variety of data sets by loading it into the client application and by applying typical GIS operations on the various overlaid data sets. Therefore, data in vector formats or well-described raster data is preferred over pure imagery data.

Regarding external data, USFWS prefers having direct access to well-maintained data offered at Web services interfaces rather than keeping local copies of full data sets that do not get maintained. In terms of imagery, accessing external services rather than maintaining local repositories frees up lots of memory space in addition. These Web services shall implement OGC standards, as those services can easily be integrated into the client applications and do not require substantial re-configuration if changes to the services are applied. In the past, several vendor-specific services became unavailable after the service software was modified. Caching of Web service data is an option, but not necessary as long as service availability and accessibility is ensured.

To exchange views on different data sets, USFWS makes us of Arc mxd-files to share layer configurations and data representations with biologists and other organizations. This approach works very well if the partnering organization uses QGIS, as appropriate plugins exist to handle mxd files. The ESRI software ArcGIS allows exchanging view configurations WMS set ups, but WFS is not supported out of the box. ArcGIS requires the interoperability extension to be installed. This ESRI issue hinders the integration of WFS services.

7.4.2 Data & Services

In terms of external data sources, USFWS cooperates with other organizations, such as the state. The state operates NC One Map, "a public service providing comprehensive discovery and access to North Carolina's geospatial data resources. NC OneMap, the State's Clearinghouse for geospatial information, relies on data sharing and partnerships." (http://nconemap.com) The platform features spatial exploration and supports searching for specific service types among other criteria. Other external data sets used include:

□ USGS NHD includes very useful layers, though receiving data from a WFS interfaces is preferred over the offered WMS, as further data analysis is constrained otherwise

☐ USGS Hydro Points (from Geonames) are very useful to identify locations referred to using historical names. This is particularly relevant in the context of permits issued at times when other names had been in place.

☐ USGS Transportation gives useful information about transportation elements, but does not always provides data at the required fine scale.

☐ USGS Administrative layer is confusing, as there is little information available on what can be done with the service

☐ USGS 24k Index[5]: The USGS 24k Topo Map Boundaries layer is a very useful data set, as an up to date version of this layer is important. It happens often that quadrangle references or references to a section on a quad-sheet are given in submissions for a specific activity.

☐ USGS Topographic Base Maps are useful, but there where mixed experiences regarding the accessibility of those data. Sometimes no data was available at all. It seemed to be a bandwidth issue that could not further be localized. It might be an internal problem to USFWS. In any case, the topographic base map layers are important information, in particular when combined with Open Street Maps data.

☐ 2012 National Agriculture Imagery Program (NAIP)[6] data is used often in conjunction with state-owned ortho-imagery, available at 6inch resolution, flown in winter 2011 and served at a WMS interface. As the NAIP data is from summer 2012, both data sets combined allow understanding changes in seasons.

☐ EPA/USGS National Hydrography Dataset plus (NHDplus)[7] catchments are an important layer, but even though the connection to the WMS was success,

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[5] "This layer presents the geographic extent of USGS 1:24,000 topographic maps (7.5- by 7.5-minute quadrangles) for the conterminous U.S. forty-eight states and District of Columbia. It provides quadrangle name, identification number, publication data, and map coverage by state for each quadrangle. This large-scale index grid is appropriate for display at more detailed scales." (http://www.arcgis.com/home/item.html?id=4bf2616d2f054fbe92eadcdc9582a765)

[6] "The National Agriculture Imagery Program (NAIP) collects leaf-on (as opposed to the more common leaf-off) aerial imagery at 1 or 2 meter resolution for the United States. This imagery is used for estimating crop plantings and yields. 2012 - statewide, 1 meter resolution, 4-band (true color and color-infrared) GeoTIFF tiles" (http://www.lib.ncsu.edu/gis/naip.html)

[7] NHDPlus is a geo-spatial, hydrologic framework dataset envisioned by the US Environmental Protection Agency. The EPA Office of Water, assisted by the US Geological Survey, has supported the development of NHDPlus to enhance the EPA Watershed Assessment, Tracking & Environmental Results (WATERS) activities and the USGS National Water Quality Assessment (NAWQA) Program's SPARROW modeling. Since its first release in 2006, NHDPlus has been made available by EPA to the wider water resources community and has been used for many diverse applications inside and outside of EPA and USGS. NHDPlus is an integrated suite of application-ready geospatial data sets that incorporate many of the best features of the National Hydrography Dataset (NHD), the National Elevation Dataset (NED), and the Watershed Boundary Dataset (WBD). NHDPlus Version 1 (NHDPlusV1) was released in 2006. NHDPlus Version 2 (NHDPlusV2) began its public debut in June 2012.

no data is available for North Carolina. In those situations, it is difficult to understand if no data means that there is indeed no data available, or if the service is malfunctioning. Catchment areas are an important data set that would ideally be served at a WFS interface.

☐ Various USGS WCS services caused various error messages, e.g. EDC Landcover.

In principle, USFWS is interested in having as many base data layers as possible that are relevant to a biologist as OGC compliant Web services, ideally WFS.

7.4.3 Recommendations

USFWS makes use of a number of USGS data services. As those services become more and more important to them, requirements for availability and reliability are high. In addition, USFWS uses several client applications, in particular QGIS and ArcGIS. It would be important to test USGS services with different versions of those clients and provide this information online. Consumers could use it to optimize their systems and make better use of the services offered.

The existing services are already of big value to USFWS. In addition to what is available, USFWS would like to get access to water gage information at a WFS interface. The USGS water resources division already makes data available as WaterML as a proprietary Web service. It would be great to have a WFS serving synoptic sampling data, including attributes for time of record, discharge, any chemical constituents analyzed, and the sampling location. If those services do exist, they are difficult to discover.

It would be helpful for users to have some sort of service availability overview informing about availability of services, as some client tools do not show any error message if no data is served. This behavior gives inconsistent experiences to users, as it is not clear if the service cannot provide any data for a particular query, or is not behaving properly. This is an issue that should be addressed by client developers as well.

USGS should consider starting a mailing list where people get notified about new services becoming available, as working routines often do not include discovery activities. For example, USFWS did not know about the availability of NHDplus catchment data served at a WFS interface. Clients use what they are used to and often only add new services if actively notified about them. Experiences in the past have even shown that catalog orchestration often does not really work. Once this issue is solved, tools could start polling for new services at a single, top-level endpoint, in contrast to many concurrent systems. As an example, USFWS currently uses ServCat[8],

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[8] The Natural Resource Program Center (NRPC) is collaborating with the National Park Service's (NPS) Inventory and Monitoring Program to create a centralized place to compile and organize information from the U.S. Fish and Wildlife Service. This repository is called the Service Catalog or ServCat - a Web application available to Fish and Wildlife Service employees that compiles documents and organizes data, such as reports, surveys, databases, geospatial data and images.

ScienceBase[9], and NC One Map, i.e. three different systems with different interfaces and APIs. Accessing all three of them through data.gov would simplify the process, but requires careful testing of service orchestration aspects.

7.5   Troup County, GA

7.5.1   Use Case

The goal is to make as many data layers available to county officials as required. Due to the lack of licenses for commercial products, county officials cannot easily access the various data layers, in particular as they are not familiar with open source or free software client applications. Therefore, the goal is to develop web based front ends to various data sets. The figure below demonstrates this approach using the USGS national elevation dataset. The client displays map data from various sources and allows drawing multi-lines on that map. The elevation data is displayed within a separate window
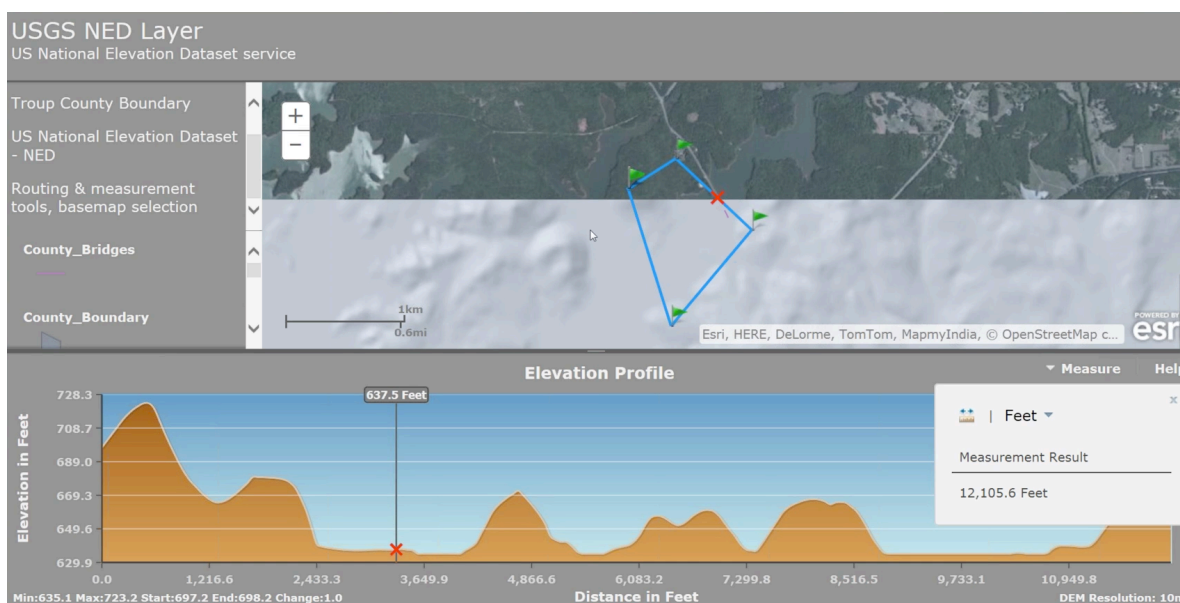

Figure 7: Troup County client to visualize elevation data using USGS NED

The front end is currently still under development. The goal is to make it available on mobile platforms and to allow capturing new data directly on the mobile device.

Other examples include an bridge one-stop shop, where all information about bridges including elevation data is made available, or various overlays of KML files with current

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[9] Science Base is a collaborative scientific data and information management platform used directly by science teams. It provides access to aggregated information derived from many data and information domains, including feeds from existing data systems, metadata catalogs, and scientists contributing new and original content.

imagery and topography data layers. The front ends are usually generated using ArcGIS Explorer.

7.5.2 Data & Services

Troup County tested different several services and experienced some problems connecting to it. The most important one is a reliable elevation data, served at a WCS interface.

7.5.3 Recommendations

Improve communications regarding planned software updates, to allow connecting/adapting to the new services once they become available.

7.6 Oregon Coastal Management Program

7.6.1 Use Case

The Oregon Coastal Management Program is a NOAA funded project that works vertically between local government along the coast and some state agency and federal partners. Horizontally, the project cooperates with counterparts in the states of California and Washington. Here, we concentrate on the West Coast Ocean Data Portal, which mainly serves as a data and services discovery portal. The portal main site is illustrated below.

Figure 8: West Coast Ocean Data Portal (http://portal.westcoastoceans.org)

The portal mostly contains ocean-related data, but can allow access to other services as well, e.g. those provided by USGS. The goal is to provide simple access to those services, serve as a one-stop shop, and advertise data and services to groups not familiar with specific data sets.

The portal is built on an ESRI Geoportal in the background, but with an entirely customized user interface. Each service or data set is registered at a CSW (OGC Catalog Service), using ISO 19115 metadata records. The catalog then allows access to the data, often through multiple formats and protocols, such as WMS, KML, JSON, zipped shape files etc.

The customers of the portal use a variety of tools to interact with the data. The state agencies of Oregon have a license agreement with ESRI and can use ESRI GIS products (ArcMap with many plugins) to work with data and services. In contrast, local governments that cannot afford expensive GIS software either use Web mapping services provided as part of the program or a combination of low-level ESRI and open source/free

software tools, with QGIS being the main tool of choice. University partners bring in additional tools, as many of them do not come from the ESRI/GIS environment.

There is an application under development called the MarinePlanner. This application is based on OpenLayers, which allows simple integration of many OGC service interfaces. The goal of this application is to make many services available at a single point of entry, allowing overlay of many services and data types. The planner allows a user to bookmark a number of search results from the portal, which are then automatically imported and visualized. In this regard, the planner works as an interactive mapping environment. The plan is to support all standard OGC service types, such as WMS, WFS, and WCS.

7.6.2   Data & Services

The platform features several viewers that mostly work with WMS instances, operated and maintained by a variety of partners. Currently, the portal does not use any of the USGS services listed on the provided overview, it would be very interesting to add WFS Geonames, NHDplus and elevation data (NED) services. In this regard, it has to be noted that WCS services can be used directly from within ArcMap, whereas WFS services require the installation of the ArcGIS Data Interoperability extension. Even though there is a version of the plugin that is offered free of charge, it is a barrier that it does not come with any of the low-level ArcMap installation packages.

7.6.3   Recommendations

In some cases, GeoJSON would be preferred as a WFS response format. This would allow using powerful tools and libraries, such as D3[10], to analyze and process the data without requiring fundamental GIS knowledge on the client side.

As a general comment, some services use numerical systems to name feature types or offered layers or coverages. This might be the default offered by the service implementation, but is not very useful for clients to work with. In this situation, clients are required to issue further requests, as there is little information that can be retrieved from sequential numbers rather than meaningful names.

7.7   NGA use of USGS Services

7.7.1   Use Case

The NGA *GeoInt App Store* (https://apps.nga.mil) serves as an aggregation portal for geospatial intelligence data and services. In this, the NGA App Store is not literally an application store, but serves as an access point to all sorts of information, such as data served at Web service interfaces operated and maintained mainly by various government

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[10] D3.js is a JavaScript library for manipulating documents based on data. D3 helps you bring data to life using HTML, SVG and CSS. D3's emphasis on web standards gives you the full capabilities of modern browsers without tying yourself to a proprietary framework, combining powerful visualization components and a data-driven approach to DOM manipulation.

organizations, ArcGIS scripts, Websites, iOS or Android applications, or any other geospatial intelligence related resources that is of value to the user community.
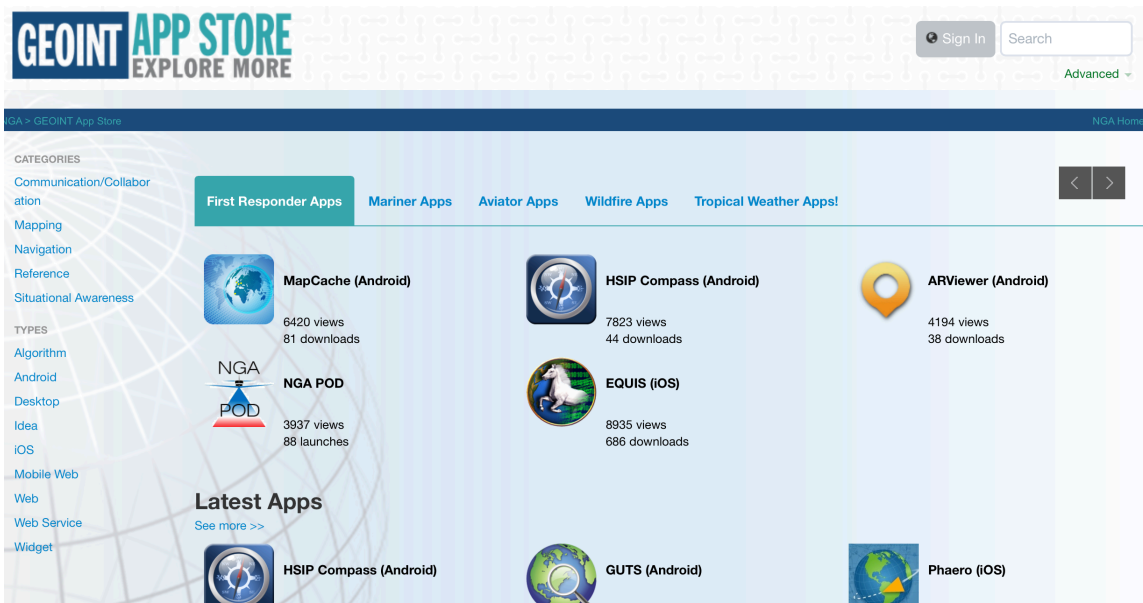

Figure 9: NGA GEOINT App Store (http://apps.nga.mil)

The app store has entries for various USGS products, such as the national map products or the USGS Natural Hazard Support System (NHSS).

In addition to exposing USGS products in the app store, various groups within NGA make direct use of USGS services. Those groups include the Integrated Working Group – Readiness, Response and Recovery (IWG-R3), basically NGA's disaster response group; DHS support teams within NGA; or FEMA liaison teams, e.g. with FEMA National Response Coordination Center (NRCC[11]).

7.7.2   Data & Services

Several groups within NGA make use of USGS products. Of particular interest are the river gauge data, GeoMAC[12] data, and data services usually consumed by first

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[11] The FEMA NRCC is a multiagency entity operating from FEMA headquarters that functions as the operational component of the DHS NOC. The NRCC coordinates personnel and resource deployments to support disaster operations and prioritizes interagency allocation of resources. It maintains situational awareness linkages with regional, state, and local partners and 24 x 7 watch team. The NRCC is staffed to support daily monitoring activities with the ability to surge in support of catastrophic events.

[12] The Geospatial Multi-Agency Coordination or GeoMAC, is an internet-based mapping application originally designed for fire managers to access online maps of current fire locations and perimeters in the United States. Using a standard web browser, fire personnel can view this information to pinpoint the affected areas. With the growing concern of western wildland fires in the summer of 2000, this application also became available to the public (http://www.geomac.gov/about.shtml).

responders. Some issues have been experienced in the past with non-matching geodetic reference systems, such as WGS84 used by USGS vs. NAD83 used by NGA.

7.7.3   Recommendations

The apps in the NGA app store are currently maintained by NGA. It would be highly beneficial if those apps could be maintained by USGS directly. An issue is automating the process of registering apps. Currently, NGA is not notified if new services come online or if existing ones get modified. One possible solution would be to modify the app store approach in a way that it harvests metadata about USGS services directly from a USGS catalog service.

Once again, the desire to add some sort of a notification service came up. The service would allow users to subscribe to changes applied to services they are using or additional services of potential relevance in their field. This would allow users to efficiently adapt to changes rather than guessing why a reliable service is not responding anymore.

8   General Recommendations

In summary, the following recommendations can be made to improve the user experience with USGS Web services:

☐   The service compliance tests have shown that many services are not fully compliant with the OGC standard being tested, with varying relevance for service usability. Testing compliance for older service specifications, e.g. WFS 1.1, is often limited due to missing conformance classes in the standard and/or limited matching between the standard, abstract test suite, and compliance tests implementation. Given the high number of existing implementations for those services (e.g. 239 WFS 1.1 implementations compared to 39 WFS 2.0 implementations), it is recommended to rework the old standards and abstract test suites and improve the service compliance test implementations. Switching to WFS 2.0 is an option, but often not necessary and causes other issues that commonly accompany new software releases, in particular in distributed environments where clients have been fine-tuned to optimize interaction with service instances.

☐   The compliance test suite for WFS 1.1 should be reworked to improve service-testing experiences for service providers, possibly developing a new conformance class. For example, Basic WFS 1.1.0.

☐   Many service instances are not fully compliant with the service specification, but still usable in practice. Therefore a categorization of test results should be considered, e.g. "blocker, critical, minor".

☐   The naming of feature types or coverages often follows an opaque naming convention. The same incomprehensible name is often used in the "Title" element and no further description is provided. Thus, it is very difficult for the user to understand what a particular data set can be used for. This is particularly true for generic client applications, such as QGIS or ArcGIS, where feature collections from WFS are loaded and quickly explored by reading the feature type names and titles or descriptions. Informative names such as "BirdHabitat" makes more sense than "cg34" and would save the user some time from running additional DescribeFeatureType requests (which have been not much more informative in some cases).

☐   As more and more services are used in complex situations, it is important to use proper namespace identifiers. Often, those identifiers change between response types. The namespace used in a GetCapabilities response should be identical with the one used in a GetFeature response.

☐   The CITE website provides direct access to the latest test suites. Those tests can be run online by simply providing the own service URL. In order to improve user

experiences, it makes sense to run those tests before publishing a service. The CITE website can be found at http://cite.opengeospatial.org.

☐ Many users discover a service through the word of mouth rather than catalogs that are consulted regularly. Therefore, it would make sense to accompany a service with some sort of message board that informs users of planned modifications to existing services are updated service offerings. Otherwise, many users give up using a particular service due to changed configurations or undocumented down times.

☐ As there is a large variety of client applications, it would be great if experiences regarding interaction of different versions of client applications with the service could be provided. Many users don't have sufficient resources to become OGC compliant Web service experts and make the decision to drop using these services when error messages occur. A simple "how to use this service" website would increase the number of users.

Annex A

Call for Participation

The call for participation is available online at Weblink[13].

Annex B

Service Tests

The detailed reports on service tests are available online at [Report 1][14], [Report 2][15]. It has to be emphasized that the tests have been performed with limited resources. The goal was to help service operators to improve their services.

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[14] https://portal.opengeospatial.org/files/?artifact_id=59834

[15] https://portal.opengeospatial.org/files/?artifact_id=59835

Bibliography

All references have been given inline

Revision history

Date	Release	Editor	Primary clauses modified	Description
11/07/2014	0.1	Ingo Simonis	All	Initial version, covers first two webinars
28/07/2014	0.2	Ingo Simonis	All	Covers all webinars and service tests.
31/07/2014	0.3	Luis Bermudez	1, 4, 6, 7	Organized 1.1 so it clearly shows the three main activities of the project. Added the section about CAT test
11/08/2014	0.4	Ingo Simonis	1, 2, 4, 5	Indices updated, minor corrections, headings modified, references updated
13/08/2014	0.5	Ingo Simonis	8	Added
17/08/2014	0.7	Luis Bermudez	7.2.3	Cleaned bullet 3
25/08/2014	1.0	Ingo Simonis	8	Complemented
28/08/2014	1.1	Ingo Simonis	All	Edits received from David Danko included, recommendations and annexes updated
02/10/2014	1.2	Ingo Simonis	All	Comments from Calgary TC considered
15/10/2014	1.3	Luis Bermudez	All	Overall revision
16/10/2014	1.4	Ingo Simonis	All	Final edits
31/01/2015	1.5	Simmons and Reed	Various	Prepare for publication