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Open Geospatial Consortium (OGC)

Request for Quotations (RFQ)
and
Call for Participation (CFP)
for
OGC Web Services Initiative - Phase 9 (OWS-9)

Annex B
OWS-9 Architecture

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 OWS-9 Introduction

A significant part of the OGC standards development process is the Interoperability Program (IP), which conducts international interoperability initiatives such as Test beds, Pilot Projects, Interoperability Experiments, and Interoperability Support Services. These activities are designed to encourage rapid development, testing, validation, demonstration and adoption of open, consensus based standards and best practices. Descriptions of these various initiatives can be found here:

http://www.opengeospatial.org/ogc/programs/ip

The OGC Web Services Initiative, Phase 9 (OWS-9), is a Test bed within the Interoperability Program. OWS-9 is a global, hands-on and collaborative prototyping activity designed for rapid development and delivery of components and services, as well as experience leading to documented best practices. The results of OWS-9 will be documented as Engineering Reports and submitted to OGC's Technical Committee for consideration for release as public documents. In the future, some of the Engineering Reports, upon formal adoption within the OGC Standards Program may become a new standard, a revision to an existing standard, or abest practice.

An index to the policies and procedures governing OGC can be found here:

http://www.opengeospatial.org/ogc/policies

The policies and procedures that define the OGC Interoperability Program are available here:

http://www.opengeospatial.org/ogc/policies/ippp

The purpose of Annex B is to describe the detailed context and requirements for OWS-9 development, which involves multiple interdependent activity threads. The requirements and architectures presented here are based upon a collaborative effort between OWS-9 Sponsors and OGC's IP program and project management staff, collectively referred to as the IP Team. The OWS-9 architecture builds on the results from previous and ongoing OGC IP initiatives, existing OGC discussion papers and specifications, OGC Technical Committee activities, and publicly available documentation from related standards organizations including ISO, W3C, OASIS, and others.

Section 2 provides an overview of the OWS-9 development threads.

Section 3 discusses the architectural approach and technical baseline for OWS-9.

Sections 4 through 8 provides the requirements, deliverables, architectural approaches and issues for each of the OWS-9 development threads.

The OGC public website provides a Glossary of Terms at the following URL that may be useful to aid in understanding and interpretation of terms and abbreviations contained throughout this RFQ:

http://www.opengeospatial.org/ogc/glossary

2 OWS-9 Thread Summaries

2.1 Aviation

The Aviation Thread of OWS-9 builds on the Aeronautical Information Management (AIM) and Aviation threads of OWS-6, OWS-7 and OWS-9 respectively as well as the FAA Special Activity Airspace (SAA) Dissemination OGC Pilot. The OWS-9 Aviation Thread seeks to further develop and demonstrate the use of the Aeronautical Information Exchange Model (AIXM) and the Weather Information Exchange Model (WXXM) in an OGC Web Services environment. Furthermore, efficient management of data transmissions between this environment and client applications deployed in aircrafts will be developed.

The work to be performed in this thread includes the following:

- **Advancing the Aviation Architecture:**
  - Functionality to support improved retrieval of aeronautical and weather information via Web Feature Service and Event Service will be investigated.
  - Representation and efficient management of metadata – including data provenance – will be explored and realized.
  - Support for efficient communication between Aviation services and clients located on an aircraft will be developed.
  - Work in the areas of discovery as well as interoperable styling and portrayal will be pursued.
  - Functionality to perform geometry processing via Web Processing Service will be integrated.
- **Advancing system stability and compliancy:**
  - The performance and endurance of critical data provisioning services – Web Feature Service and Event Service - will be tested and analyzed.
  - Conformance tests for Web Feature Services serving aeronautical information will be developed.
- **Advancing modeling tool support:**
  - Investigation and development of conceptual modeling and mapping tool support.

2.2 Cross-Community Interoperability (CCI) Thread

The Cross-Community Interoperability (CCI) thread seeks to build on the CCI work accomplished in OWS–8 by increasing interoperability within communities sharing geospatial data. This thread will advance semantic mediation approaches for data discovery, access and use of heterogeneous data models and heterogeneous metadata models. The work to be performed in this thread includes the following:

- **Semantic mediation**:
  - Advancement of semantic mediation approaches to query and discover data, which have been described using different metadata models, including non-traditional OGC metadata models.
  - Advancement of semantic mediation approaches to query and discover data, which have been described using different data models, including non-traditional OGC data models.

- **Query Results Delivery**
  - Advancement of using Security to filter and route query results.
  - Advancement of using OWS-Context for results delivery.
- **Data Provenance and Quality:**
  - Advancement of using a web based data processing facility for managing and visualizing provenance and quality of data.
  - Advancement of managing data provenance in OGC Web Services.
- **Single Point of Entry Global Gazetteer (SPEGG)**
  - Advancement of semantic mediation approaches to provide a Single Point of Entry Global Gazetteer.

2.3 Security and Services Interoperability (SSI) Thread

The OWS-9 SSI thread contains 5 major objectives: Security Management, GML Application Schema UGAS Updates, Web Services Façade, Reference Architecture Profiling, and Bulk Data Transfer:

- **Security Management:** Builds on and extends on the OWS-6 Security thread. Security management will be based on WS-Federation for Web service (SOA) transactions. Authentication and authorization functionality will include role-based and attribute-based rules indicating where a user and SOA Consumer is authorized access to particular services or particular data content.
- **GML Application Schema UGAS updates:** Builds on the OWS-9 Schema Automation activity for improved schema automation supporting SWE common 2.0 with an open source UML-to-GML Application Schema (UGAS) tool. Add - UML to JSON capabilities.
- **Web Services Façade:** Builds a tool for web service developers to implement as a façade to the service capable of translating a request from one binding format into a binding format which is supported by that OWS service
- **Reference Architecture Profiling:** Evaluates the content of the IC/DoD Content Discovery and Retrieval Reference Architecture against the OGC Reference Architecture incorporating ideas and content as appropriate.
- **Bulk Data Transfer:** Loosely builds upon the OWS-9 GeoSync activity investigating data transfer. This objective will explore streaming solutions, and real time data updates to be usable on in conjunction with any devise, while ensuring data integrity and precision.

2.4 OWS Innovations Thread

As a thread of activity in OWS-9, OWS Innovations explore cutting edge topics, and those that require the most experimental, research-oriented approaches. The topics found in this thread represent either new areas of work for the Consortium (such as GPS and Mobile Applications), a desire for new approaches to existing technologies to solve new challenges (such as the WCS work), or some combination of the two.

This thread is segmented into four overarching topics: Geospatial Mobile Applications; Web Mapping; Coverage Access and Data Quality; and a GPS Study. Each of these objectives are described in greater detail below:

- **Geospatial Mobile Applications:** OGC seeks to further understand the requirements for developing standards-based geospatially-enabled mobile applications. Of particular interest is defining a best practice or standard for OGC web service mobile applications to consider such elements as certification and accreditation, security, quality of results, ease of operation, service descriptions, etc. Additional interest is in the area of defining an interoperable data structure for integrated feature, map and coverage data for handheld devices. The intent is to specify a simple structure to support data downloaded and cached onto a then disconnected mobile device that can collect data in a disconnected environment and synchronize the new data to master databases upon reconnection to the Internet.

- **Web Mapping:** Diverse competing and sometimes complementary raster data tiling schemes now exist in the marketplace, including WMTS, Tile Map Service (OSGeo), MBTiles, TileCache (MetaCarta), and various others. Participants shall evaluate these approaches and recommend alignment. We will also begin to look at ways to express data quality in OGC services and encodings, beginning with WMS, WMTS and KML.

- **Coverage Access and Data Quality:** A number of different data formats designed for specific-purpose use may be suitable for integration into an OGC Web Services environment. In this Testbed we look at NITF, LIDAR, and DAP/OPeNDAP, and investigate their re-implementation in an OWS environment with a focus on the Web Coverage Service 2.0 standard.

- **GPS Study:** Advances in GPS technology and new demands on the existing system have created the need for modernization efforts to implement the next generation of GPS. In this Testbed, participants will investigate the capabilities of OGC standards to support GPS data product and message requirements to include definition of a new one-size-fits-all Variable Message Format (VMF) message capable of supporting all potential GPS ephemeris/data.

2.5 Compliance & Interoperability Testing & Evaluation (CITE) Thread

The CITE thread will develop a suite of compliance test scripts for testing and validation of products with interfaces implementing the OGC specifications listed below. These scripts will be written for new Testing, Evaluation, and Measurement (TEAM) engine in CTL. The participants in this thread will develop test scripts. These Test scripts will be presented to the Technical Committee and Planning Committee for approval. All development activities within the CITE thread should result in products that are fully functional on a Linux platform on the OGC IT infrastructure.

The OWS-9 CITE Thread will develop Compliance elements in these areas:

- WMS 1.3 Server
- WMS 1.3 Client
- WFS 2.0
- GML 3.2.1
- OWS Context 1.0
- SWE
- WCS –EO 1.0
- TEAM Engine Capabilities

2.6 Types of Deliverables

The OWS-9 threads require several types of deliverables in each Thread:

- **Documents - Engineering Reports (ER), Information Models (IM), Encodings (EN), Change Requests (CR):** will be prepared in accordance with OGC published templates. Engineering Reports will be delivered by posting on the OGC Portal Pending Documents list when complete and the document has achieved a satisfactory level of consensus among interested participants, contributors and editors. Engineering Reports are the formal mechanism used to deliver results of the Interoperability Program to sponsors and to the OGC Specification Program Domain and Specification Working Groups for consideration.

- **Implementations - Services, Clients, Datasets and Tools:** will be provided by methods suitable to its type and stated requirements. For example, services and components (ex. WFS) are delivered by deployment of the service or component for use in the testbed via an accessible URL. A Client software application or component may be used during the testbed to exercise services and components to test and demonstrate interoperability; however, it is most often not delivered as a license for follow-on usage. Implementations of services, clients and data instances will be developed and deployed in the Aviation thread for integration and interoperability testing, in support of the agreed-up thread scenario(s) and technical architecture. The services, clients and tools may be invoked for cross-thread scenarios for OWS-9 demonstration events

Note that certain draft deliverables must be completed by the Preliminary Design and Deliverables milestone to support OWS-9 cross-thread development. These early deliverables are designated in the Thread deliverable sections.

3 OWS-9 Baseline

3.1 OGC Reference Model

Reference: OGC Reference Model version 2.1, document OGC 08-062r7

http://www.opengeospatial.org/standards/orm

The OGC Reference Model (ORM) provides an architecture framework for the ongoing work of the OGC. Further, the ORM provides a framework for the OGC Standards Baseline. The OGC Standards Baseline consists of the member-approved Implementation/Abstract Specifications as well as for a number of candidate specifications that are currently in progress.

The ORM is a living document that is revised on a regular basis to continually and accurately reflect the ongoing work of the Consortium. We encourage respondents to this RFQ to learn and understand the concepts that are presented in the ORM.

The structure of the ORM is based on the Reference Model for Open Distributed Processing (RM-ODP), also identified as ISO 10746. This is a multi-dimensional approach well suited to describing complex information systems. This Annex of the OWS-9 RFQ will use one or more of the upper four viewpoints of RM-ODP: Enterprise, Information, Computational, and Engineering, as shown in the figure below, for discussing the context for each activity thread in OWS-9.

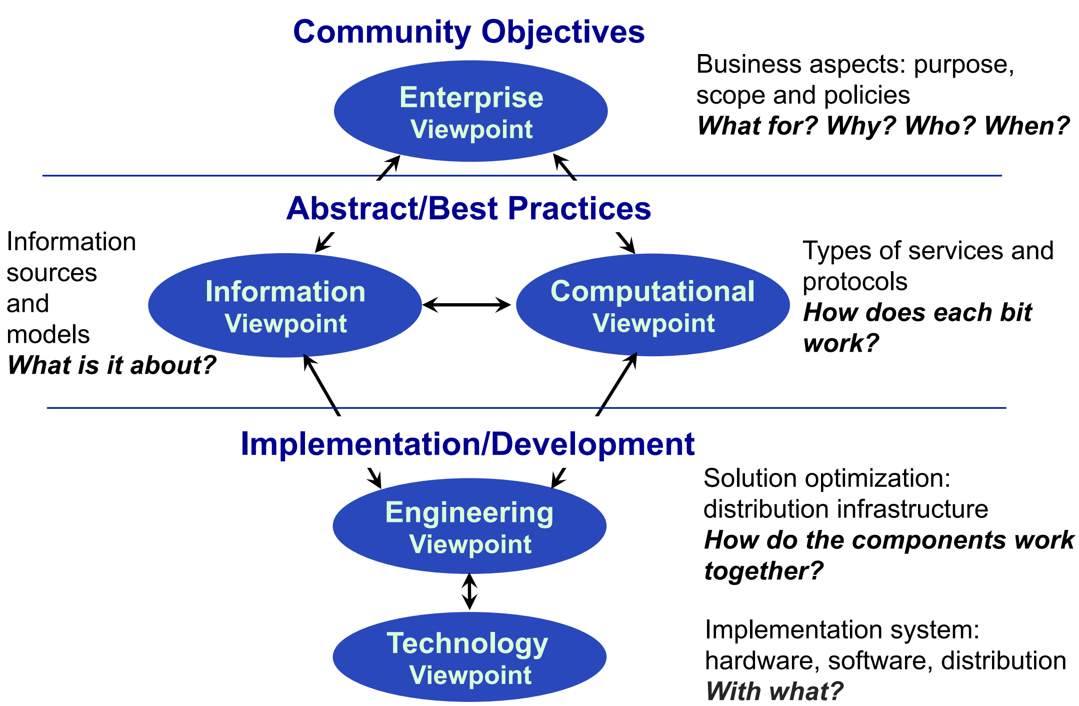

Figure 1 – RM-ODP Viewpoints used in OGC Reference Model

3.2 OGC Standards Baseline

The OGC Standards Baseline is comprised of all member-approved Implementation Standards, Abstract Standards, and Best Practices documents. These standards and related documents are freely available to the public at this website:

http://www.opengeospatial.org/standards

Each major section of the thread descriptions below identifies the relevant standards and other useful references, both normative and informative. The context of the description will make it clear whether a standard is normative (normally expressed as "will" or "shall" be used) or informative ("may" or "should").

3.3 GML and Profiles

All threads using GML are expected to use version 3.2.1, which has also been approved as an ISO standard (ISO 19136:2007). Attention is called to the fact that numerous GML Profiles (functional subsets of GML designed for specific applications) have been developed, which are currently based on GML 3.1.1, as evident on the GML web page: http://www.opengeospatial.org/standards/gml. Presumably these may need only minor changes to become compliant with GML 3.2.1, and in some cases an OGC Standards Working Group may be updating a profile needed in a thread activity. In the case of GML Simple Features Profile (see OGC 10-100r2), the Profile has recently been brought into compliance with GML 3.2.1. The updated specification has been voted and approved, but at the time of this RFQ release, the final editing changes required to post the adopted specification on the public website are still in process. In all cases of GML Profile usage, be sure to check on the possibility that an updated profile is in development, and consider the maturity of the new profile for use in your thread activities. Any changes made to bring a profile into compliance with GML 3.2.1 during OWS-9 should be documented as a Change Request to the appropriate OGC Working Group, following the procedure available to the public here: http://portal.opengeospatial.org/public_ogc/change_request.php.

In case of any questions or for access to the most current specifications, please contact the OGC Technology Office (techdesk AT opengeospatial.org).

3.4 OGC Best Practices Baseline

Best Practice Documents contain discussion of best practices related to the use and/or implementation of an adopted OGC document and for release to the public. Best Practices Documents are an official position of the OGC and thus represent an endorsement of the content of the paper. These Best Practice Documents have been made available at the following website: http://www.opengeospatial.org/standards/bp. Each thread mentions any recommended Best Practices documents in the relevant discussion section.

3.5 OGC Public Engineering Reports Baseline

OGC Public Engineering Reports (ER) and Discussion Papers (DP) are documents that present technology issues being considered in the Working Groups of the Open Geospatial Consortium Technical Committee. Their purpose is to create discussion in the geospatial information industry on a specific topic. These papers do not represent the official position of the Open Geospatial Consortium nor of the OGC Technical Committee. The following set of ERs are publicly available at this website:

http://www.opengeospatial.org/standards/per

Additional Engineering Reports, Discussion Papers, and Interoperability Program Reports resulting from test beds prior to OWS-6 are publicly available at this website:

http://www.opengeospatial.org/standards/dp

These are placed here for reference-specific requirements mentioned in some of the threads. These are not all required or normative. Schemas for some of these documents can be found at the Discussion Paper Schema Repository.

4 OWS-9 Thread: Aviation

4.1 Aviation Thread Scope

The Aviation Thread of OWS-9 builds on the Aeronautical Information Management (AIM) and Aviation threads of OWS-6, OWS-7 and OWS-8, and seeks to further develop and demonstrate the use of the Aeronautical Information Exchange Model (AIXM) and the Weather Information Exchange Model (WXXM) in an OGC Web Services environment.

In OWS-9, the goal of the Aviation Thread is to further advance AIXM and WXXM and their use in an OGC Web Services environment, in the following areas:

- Advancing the Aviation Architecture
  - 4.2.2.1 Advance interoperable data retrieval
  - 4.2.2.2 Mature metadata use
  - 4.2.2.3 Develop interoperable data transmission to aircraft management
  - 4.2.2.4 Advance discovery interoperability
  - 4.2.2.5 Advance interoperable styling and portrayal
  - 4.2.2.6 Integrate geometry processing services
- Advancing system stability and compliancy
  - 4.2.3.1 Investigate system performance and endurance
  - 4.2.3.2 Mature system conformance
- Advancing modeling support
  - 4.2.4.1 Advance conceptual modeling and mapping tool support

To test and demonstrate work performed in the above areas, one or more scenarios will be developed, refined and used as high-level objectives for organizing the work in the Aviation Thread and as the basis for the final demonstrations of the results. The scenario(s) will exercise a variety of web services utilizing the AIXM and WXXM encodings. With respect to data sources:

- Existing data sources should be used to the extent possible to test the requirements and support the thread scenarios.
  - Note: in previous testbeds, participants contributed data sources to the Aviation Thread activities. If you can contribute data to OWS-9 Aviation in-kind, indicate this in your proposal – providing details about the availability (publicly usable, non-disclosure agreement required, usage instructions to be noted – for example “for non-operational purposes”, etc.), content (static and/or dynamic aeronautical feature data, weather data), format (e.g. AIXM 5.1, WXXM 1.1.3) and extent (e.g. airports in Europe, airspaces in Asia, weather for Europe).
- As needed, FAA and EUROCONTROL may provide access to AIXM and WXXM files that contain sample aeronautical data (static and dynamic).
- The thread participants may need to convert some existing source data into AIXM/WXXM-compliant formats.

- For testing purposes – especially performance and endurance tests - the thread participants may have to create ad-hoc AIXM 5.1 / WXXM 1.1.3 data based on the data provided by the sponsors.

4.2 Aviation Thread Requirements

The following sections define the requirements for the OWS-9 Aviation Thread.

4.2.1 Getting Access to SESAR Reference Material

Several SESAR documents are referenced in the Aviation Thread. To receive SESAR documents, send an email to techdesk@opengeospatial.org and the documents will be sent along with direction that the receiving organization is not permitted to send the document to any third parties without the prior approval of EUROCONTROL. Additionally, the receiving organization must abide by the Intellectual Property Requirements listed in the SESAR documents.

4.2.2 Advancing the Aviation Architecture

4.2.2.1 Advance interoperable data retrieval

References

- SWIM Service Compliance Requirements - http://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/techops/atc_comms_services/swim/documentation/media/compliancy/SWIM%20Service%20Compliance%20Requirements.pdf

- Systems Rules Model (SRM) – see chapter 10 (especially data filtering and management of subscription / data request configurations)

- OWS-8 Aviation Architecture Engineering Report (available on the OGC homepage)

Background

In OWS-6 to OWS-8 as well as the FAA SAA Dissemination Pilot, aeronautical as well as weather information were made available via a WFS and an Event Service. The information was encoded in AIXM and WXXM, respectively. Both WFS and Event Service support filtering functionality based on the OGC Filter Encoding (FES) – including (logical combinations of) temporal, spatial and comparison operators. Filter expressions are used to identify feature instances that are of interest to the client.

Aeronautical features like airspaces can have multiple component objects with different altitudes. Furthermore, special values – such as GND, UNL, FLOOR, CEILING – are used in AIXM 5.1 to express altitudes. The filter expressions to identify relevant features based on the vertical extent of their components can therefore become quite complex. Clients need a simple means to query aeronautical features based upon filters that take the vertical extent of the feature into account.

In order to facilitate the use of WFS to perform common data retrieval tasks, WFS 2.0 supports the concept of stored queries. These queries can be used as a simple means to execute common but complex filter expressions. In order to execute a stored query, clients

simply provide the values of a limited set of well-known variables. The service then applies these values in the according filter expression, executes it and returns the result. Such a feature is useful to simplify the development of client software which performs data retrieval tasks that are common and well-known to an application domain - like Aviation. The feature would be even more beneficial if it can be enhanced to support dynamic creation and re-use of user-configured (thus not pre-configured) stored queries.
The development of a similar mechanism for the Event Service would be equally beneficial for aviation applications. At an Event Service, subscriptions can contain complex filter expressions as well. Therefore, a kind of "stored filter" similar to the stored queries from WFS is important, including enablement of similar management capabilities (e.g. to dynamically create a stored filter).

An alternate means of specifying filter parameters for AIXM airspace features is to build AIXM support into a WFS implementation more directly. In other words, in addition to support for generic geometry operands such as gml:Point, gml:Curve, and gml:Polygon, support for AIXM-specific features such as aixm:Airspace to be used directly as geometry operand, could be provided (and advertised in the WFS Capabilities document). This relieves clients working with AIXM from having to translate the AIXM feature geometries to an equivalent OWS Filter syntax, simplifying client applications in a similar fashion as the stored query approach.

Furthermore, in order to reduce bandwidth consumption and noise caused by frequent notifications published by the Event Service, a client may want to restrict the update rate of certain types of information (e.g. weather reports) from "each update" to "last relevant update within a set time interval". Clients would thus be able to identify the frequency in which they need to receive updated information.

<u>OWS-9 Requirement</u>

The Aviation Thread of OWS-9 shall advance the interoperable provision of aeronautical and weather information.

More specifically, the Aviation Thread of OWS-9 will:

- Make aeronautical and weather information and information updates (formatted as AIXM, WXXM and Digital NOTAM) accessible via WFS 2.0 and Event Service.
    - Test/demo data provided for OWS-9 Aviation shall be imported into the WFS-T component(s) data store and made available via the WFS-T interface.
    - Information updated at WFS, for example the change of an aeronautical feature property value, shall be communicated via the Event Service interface.
    - Note: enhanced filter functionality at Event Service may require the realization of event enrichment functionality. Developments from OWS-8 (see OWS-8 Aviation Architecture ER section 9.5) can be used as a starting point.
- Common filter functionality (defined by FES 2.0) shall be supported including, but not limited to:
    - (logical combinations of) spatial, temporal and comparison operators.
    - Filtering data within a geo-referenced area, e.g. X miles either side of route and including vertical range for a 3-D area. The enhancements for supporting altitude queries shall be taken into account.
- Develop, test and document an approach for enabling more simple filtering of aeronautical feature data based upon filter expressions that take the vertical extent of the feature into account, especially considering:

  - That aeronautical features may have multiple component objects with different altitudes.
  - That altitude may be expressed with special values (GND, UNL, FLOOR, CEILING).
  - Note: high-level use case descriptions for altitude queries are provided in section 4.4.5.2.
- Develop, test and document an approach for enabling filtering of non-spatial features (e.g. runway, taxiway, apron), for example performing a spatial query for a Runway.
  - Note: a high-level use case description for non-spatial feature queries is provided in section 4.4.5.3
  - The intention is to simplify spatial filtering of AIXM features that do not contain the properties that define their spatial extent themselves. In the AIXM model, often other features that reference the non-spatial feature provide information about the extent. This problem has been investigated in previous testbeds. A solution that is simple to use for clients and at the same time feasible for the service to implement as well as being compatible to existing standards is needed.
- Develop, test and document an approach to perform filtering at WFS with FES filter expressions using AIXM features as geometry operands directly.
  - AIXM features to support include, but are not limited to, the AIXM Airspace.
  - Investigate and document the pros and cons of implementing support for filtering using AIXM feature geometries as geometry operands in a WFS implementation to support retrieval of WXXM-formatted data.
  - An implementation using this approach could be treated as an aeronautical extension to a WFS or the FES, implemented as a plug-in.
  - Other implementation strategies can also be considered.
  - Document the pros and cons of this approach when compared with the stored query approach.
  - A test of the capability to filter data in a 2.5-D polygon region corresponding to one of the ARTCC regions in the National Airspace should be a goal of the effort, but may be omitted if the necessary modification of a WFS implementation is judged to be too complex.
- Investigate, test and document how WFS stored queries can be used or enhanced to facilitate the execution of common data retrieval tasks at WFS 2.0. More specifically:
  - Develop a set of queries that are common in Aviation and make them available via WFS.
  - Optionally: enable clients to create stored queries dynamically.
  - Demonstrate the use of stored queries by clients.
- Develop, test and document how Event Service stored filters can be used to facilitate the creation of subscriptions for common information needs. More specifically:
  - Develop a set of filters that are common in Aviation and make them available via Event Service.
  - Optionally: enable clients to create stored filters dynamically.
  - Demonstrate the use of stored filters by clients.
- Develop, test and document how a client can receive notifications from the Event Service in specific update intervals as defined for the according subscription.
  - This may involve event processing functionality but could also be a simpler add-on to the basic publish/subscribe functionality of the Event Service.

- Analyze and document to which extent the OWS-9 component(s) are SWIM compliant, based upon the requirements defined in the *SWIM Service Compliance Requirements* document.
- Document potential enhancements and issues that were identified by the OWS-9 Aviation participants during the realization of this requirement in change requests against relevant OGC documents, especially Standard and Best Practice documents.

4.2.2.2 Mature metadata use

References

- Guidance on the Aviation Metadata Profile (available as OGC Discussion Paper)
- Requirements for Aviation Metadata (available as OGC Discussion Paper)
- OWS-8 AIXM Metadata Guidelines Engineering Report (https://portal.opengeospatial.org/files/?artifact_id=45380)
- NNEW Metadata Guidelines, Version 2. (https://wiki.ucar.edu/download/attachments/23364539/ATC-354-Version2.pdf?version=1&modificationDate=1279902030000)
- Systems Rules Model (SRM) – see chapter 10 (especially data provenance)

Background

AIXM as well as WXXM make use of ISO 19115 and ISO 19139 to represent and to encode metadata such as temporal reference (e.g. date of creation, date of publication) as well as data quality and provenance (e.g. lineage).

Being able to identify the originator of aeronautical information and to trace the ownership and history of the data (e.g. the processing steps applied on a set of source data to compute the given dataset) is a key aspect in aviation systems.

Furthermore, there are use cases which require all, some or none of the information contained in aeronautical and weather data to be delivered to clients. This is especially the case for ground to air communications. Efficiently providing metadata as required by the given use case is thus another important aspect.

Lastly, OGC Web Services such as WFS and WCS currently provide dataset-level summary metadata via the GetCapabilities operation (and in the case of WCS, the DescribeCoverage operation as well). Though aligned to some extent with the ISO 19115/19119 models, no means of accessing metadata encoded as ISO19139 exists. Being able to retrieve dataset-level metadata explicitly in ISO 19139 format would simplify a number of use cases, such as the mining of metadata by registry tools that are ISO 19139-capable.

OWS-9 Requirement

The Aviation Thread of OWS-9 shall investigate and test how metadata on aeronautical and weather information and especially provenance information can best be represented and how it can be efficiently managed and provided by the system.

More specifically, the Aviation Thread of OWS-9 will:

- Investigate how metadata can be used to describe aeronautical and weather information including, but not limited to, the temporal reference, quality, source/owner as well as generation and maintenance of data provenance. The analysis of data formats and encodings for representing the metadata information shall include, but is not limited to, ISO 19115 / ISO 19139 (both of which are used in and AIXM 5.1 and WXXM 1.1.3).

- Metadata for aeronautical and weather information shall conform to the requirements and guidance provided by the Aviation DWG, enhanced as necessary to fulfill OWS-9 requirements.

- Investigate and document how metadata guidance provided by the Aviation DWG aligns with the ISO 19115/ISO 19139 guidance provided by the FAA's NNEW program. The NNEW guidance for ISO 19115/19139 metadata focuses on high-level dataset series and service-level metadata rather than feature-level metadata, in support of discovery use cases. The analysis shall include a summary of how the two sources of guidance are aligned (or not), with suggestions for improved harmonization where appropriate. The NNEW metadata guidance is available on the NNEW Wiki at the link provided above in the references section.

- Investigate and document how ISO 19139 formatted metadata for dataset and service-level metadata could be retrieved directly from OGC services. Additional service operations, separate from GetCapabilities, should be considered, as should the use of stored queries. The investigation should focus on a relatively generic capability, not tied to a particular OGC service type, though the WFS and WCS specifications should be the initial focus.

- Investigate and test how services (WFS-T 2.0 & Event Service) can dynamically provide aeronautical and weather information encoded in AIXM 5.1 and WXXM 1.1.3 to their clients - with and without metadata as requested by the client (e.g. via an appropriate parameter in a WFS-T 2.0 GetFeature request or in an Event Service subscription).

    - If the user selects to receive metadata allow them to limit the amount of metadata received by selecting what features they want to receive metadata for. An example would be a user subscribing to airspace changes may only be concerned with the metadata for the Airspace feature, but they may not care about the metadata of features associated to that Airspace.

    - Note: fine grained provision of metadata may be achieved via the improved data filtering functionality that is the subject of requirement Develop interoperable data transmission to aircraft management (see section 4.2.2.3).

- Investigate and document alternative approaches for efficiently encoding, managing and providing metadata on aeronautical and weather information, especially provenance information. A suggested approach should be compatible with metadata standards used by AIXM 5.1 and WXXM 1.1.3. The primary efficiency factor/objective is to minimize the bandwidth required to communicate metadata information, for example in ground to air communication.

    - Note: an actual demonstration of these alternative approaches is desired but not required.

- Document potential enhancements and issues that were identified by the OWS-9 Aviation participants during the realization of this requirement in change requests against relevant OGC documents, especially Standard and Best Practice documents.

- Note: representation and management of metadata, especially data provenance, is also a topic of the OWS-9 CCI Semantic Mediation / Provenance Thread and thus the developments on metadata in the OWS-9 Aviation and OWS-9 CCI Semantic Mediation / Provenance threads shall be harmonized.

4.2.2.3 Develop interoperable data transmission to aircraft management

References

- Systems Rules Model (SRM) – see chapter 10

- OWS-8 AIXM 5.1 Compression Benchmarking ER (available on the OGC homepage)

Background

One important consideration in the design of the OWS-9 Aviation Architecture is the impact of component communications on a bandwidth-constrained network link, such as the link between an aircraft and the ground segment. One approach to reduce bandwidth consumption is to compress data before it is sent via the network. OWS-9 studied the results of several compression techniques.

Reducing the bandwidth required to exchange data can improve the data throughput between components. At the same time, care needs to be taken so that the processing required to compress and un-compress data does not impact the responsiveness of a given component. For example, a service component that requires the major part of its computing resources to compress responses may no longer be able to handle a sufficient number of client requests. It may also take too long to generate and deliver a response. The best approach for using compression thus depends on the characteristics of the chosen compression technique as well as the use case and available network link.

The information exchanged with or received from information management services usually is verbose and often contains information that is irrelevant to fulfill the information need of a client. For example, a client may only be interested in the actual availability of a specific airport during a given time interval (e.g. to identify if any of the airports that are relevant to the flight [destination airport and alternate(s)] is no longer available). Even though WFS and Event Service to date offer some functionality to subset feature data before it is returned/sent to the client, neither offer a generic way to minimize the information that is delivered to a client. This is also true for other information management services. The resulting communication overhead can become critical in bandwidth limited environments, especially in communications between an aircraft and the ground segment. Therefore, generic functionality to extract and also to densify the relevant information before it is delivered to the client via a limited bandwidth connection is needed.

Another way to reduce the amount of irrelevant data delivered to a client is to determine whether a piece of information is still valid. For example, an update to the status of an airspace is irrelevant for a flight if the valid time of the update is before or after the planned flight time (with a certain amount of time added to the flight time to take into account any delay).

Communication with an aircraft via wireless data link also involves additional aspects. On the one hand, the system needs to ensure that no data sent to the client is lost. Communication disruptions – for example due to complete loss of network connection or a migration of the client from one network to another – need to be managed. On the other hand, some type of information may be more critical to a client and thus the system needs to ensure that high-priority information is delivered first while the delivery of information with lower priority is delayed. Such an approach needs to take into account that the priority of data may change over time and also depend on the actual use case. Furthermore, the system should monitor network performance to report if a significant degradation in the timely delivery of information was observed.

Data quality and provenance are important elements for an aircraft accessing/receiving data from information management services. The aircrew receiving data from these services will ultimately make decisions based to some degree on the data they receive. Additionally, this data may have passed through several processing steps during the communications process. For example, it may have been reduced to remove irrelevant information as outlined before. An efficient coding method would be extremely useful in assisting the aircrew to determine the pedigree and quality of the data and its suitability for decision-making.

Finally, the pilot-in-command and the dispatcher have a joint responsibility for the safe operation of the aircraft. As such, the dispatcher needs to be aware of the information sent to the aircraft to be able to make well-informed decisions. This can be satisfied by ensuring that the dispatcher is provided with a means for synchronization, i.e. being able to get (possibly a subset of) the information that is sent to the aircraft.

OWS-9 Requirement

The Aviation Thread of OWS-9 shall investigate and develop an interoperable solution called Data Management Service (DMS) for the efficient management of data transmission between clients located on an aircraft and the information services located on the ground (Figure 15). The DMS may be but does not need to be a standalone web service. It can also be a set of services / service interfaces – however, usability of the envisioned solution is a key factor. More specifically, OWS-9 Aviation will:

- Investigate, develop, demonstrate and document a recommended approach for efficiently managing communications between clients and information management services via wireless data link. This includes:
    - Data management service functionality (for both clients and DMS) to handle breaks in communication, for example due to total loss of connectivity or a switch from one communication network to another, possibly resulting in an IP change of the client. Reliable messaging may serve as a starting point to realize this functionality.
      Basically It may also be possible to anticipate an IP switchover, which could then be used to enable smart IP routing.
      DMS and clients shall ensure that data transmissions are not lost but are instead delivered as intended by the system. Identification that a message has been lost may also involve an evaluation of message content and context, for example to determine that a message refers to prior content such as a Digital NOTAM or Temporary Flight Restriction (TFR) that has not been received.
    - Data management service functionality (for both clients and DMS) to determine the priority of data packets exchanged between client and DMS so

that data transmissions are optimized based upon available network resources and information requirements.
    - Ensuring that the dispatcher is aware of the data that is retrieved from the information management services and sent to the client (located on the aircraft). The required synchronization functionality shall be achieved by sending copies of data retrieved by the client to the dispatcher. The process of synchronization through data copies shall be extended to support delivery of only a data summary (with sufficient information to request the full data) and delivery of only selected types or classes of data. These are the minimum features required to enable efficient data synchronization for the dispatcher. The solution should enable configuration of the synchronization level of detail (full copy, summary, specific types of data etc.) as required by the given use case.
- Investigate, develop, demonstrate and document a recommended approach for improving the efficiency of data exchanges in an air-to-ground data link via DMS.
    - Expand the outcomes of the compression benchmarking study from OWS-9 to reduce bandwidth consumption through application of appropriate compression techniques in communications between clients and the information management services. The compression techniques to be supported by the DMS and clients include, but are not limited to, *FastInfoset with deflate post compression* (recommendation of the OWS-8 AIXM 5.1 Compression Benchmarking ER).
        - Note: requiring FastInfoset with deflate post compression guarantees that DMS and client components do not support completely different compression techniques. Consequently, interoperability testing can at least be performed based upon this compression technique.
    - Investigate more efficient protocols for exchanging messages between client and information management services from ground-to-air and air-to-ground. This may include application protocols other than HTTP (but TCP/IP based) as well as encodings other than GML/XML.
    - Perform an analysis of alternative solutions.
    - Perform a sensitivity analysis to describe the key drivers of significant changes.
    - Test and document the performance improvements of alternative solutions.
    - Demonstrate the recommended solution
    - Document recommendations for minimizing bandwidth impacts for ground to air and air to ground communications via DMS.
- Develop, test and document DMS functionality for filtering information sent to the client. This involves extracting relevant information (essentially performing a projection) and performing densification (example: computing trend, average value, standard deviation value, range of values) on data/responses before they are actually sent to the client. The solution shall expand or develop user configurable filtering parameters as described in the Systems Rules Model. More specifically:
    - For extracting:
        - Sophisticated means for a fine grained projection of response data shall be established. This encompasses but is not limited to the selection of feature property values that are valid for a given time interval. The solution shall for example be able to extract only the identifiers of the features that would be returned in a WFS GetFeature response.

        - The solution shall be applicable to the content of any XML based response. However, solutions for information management services with binary responses may also be considered. Use of a general XML technology may therefore be applicable.
    - For densification:
        - If multiple values are provided for a single feature property or multiple features (e.g. located in the same region) share a common property: enable selection of average value, standard deviation value, range of values, or preferred provider(s) (i.e. take property values from identified features and/or take subset of the values for a feature property with max occurrence >1).
    - Filtering of data shall also be performed by type or class of the data, issue time as well as effective and expiration time (see Systems Rules Model for further details). This information may need to be added to / automatically computed for the information that is to be exchanged between DMS and clients.
    - Develop, test and document an approach to facilitate the execution of common data filtering tasks at DMS. The envisioned functionality is similar to WFS stored queries.
    - Demonstrate the recommended DMS data filtering capabilities.
- Develop, test and document DMS functionality for validating information exchanged between the DMS and the client. The solution shall expand or develop data validation functionality as described in the Systems Rules Model. More specifically:
    - Parse message content to determine validity and currency of messages to determine whether:
        - Data has been delivered within its effective timeframe.
        - Data represents the most up-to-date information.
        - Subscribed update intervals (see section 4.2.2.1) are being complied with.
    - Demonstrate the recommended DMS data validation capabilities
- To support DMS requirements, investigate, test, demonstrate and document the inclusion of arbitrary header / metadata fields in messages exchanged between DMS and client/dispatcher. These fields shall be used to store information including, but not limited to, in support of functionality to realize data synchronization, validation, filtering, prioritization, security, authoritativeness and data link SLA provisioning functionality (see SRM for further information).
    - Note: it may be possible to encode some of this information in AIXM/WXXM data itself; whether this is feasible, especially considering a general data transmission functionality that may not only be concerned with exchange of AIXM/WXXM information, shall be investigated in OWS-9
- Investigate, develop, demonstrate and document a recommended approach for using metadata at DMS to keep track of quality and provenance information.
    - This is especially required for keeping track of modifications (e.g. filtering) performed by the DMS itself.
    - The DMS shall record relevant provenance information. It should enable operators to configure what type or class of information will have provenance associated with it. The DMS itself or some other service component shall provide access to the recorded provenance data.
    - The metadata coding schema shall be ISO 19115 / ISO 19139, which is in line with the metadata representation of AIXM and WXXM.

  - The approach shall leverage and build on the AIXM metadata profile currently under development in the Aviation Domain Working Group.
  - Develop a proposed method to provide metadata that is compatible with AIXM / WXXM as well as ISO and OGC standards while satisfying the AAtS interest of minimizing communications bandwidth.
  - Alternative representations and management approaches may be analyzed. The results of such an analysis shall be documented.
  - The recommended approach shall be harmonized with the general metadata work performed in OWS-9 Aviation and the OWS-9 CCI Semantic Mediation / Provenance thread.
  - Demonstrate the recommended approach.
- The solution should be based on open standards.
- The solution as well as identified alternatives shall maintain the interoperability between clients and information management services.

4.2.2.4 Advance discovery interoperability

References

Note: to access the following SESAR references follow the instructions in Section 4.2.1.

- SESAR 08.03.02 D03 – SWIM Registry Concept of Operations V1
- SESAR 08.03.02 D04 - AIRM/ISRM Registry - Operational Requirements and Demands concerning ATM information Catalogue and Registry Services
- SESAR 08.03.02 D08 – Registry Demonstrator Technical Report

Background

The purpose of SESAR Project 08.03.02 is to document a complete proposal concerning European ATM Information Catalogue and Registry function. In that context, project 08.03.02 kicked off a “SWIM Registry Demonstrator” initiative, which has the following objectives:

- Help refine the requirements specification for the 08.03.02 registry definition project
- Demonstrate the value of registries supporting the lifecycle of standards and services
- Demonstrate the added value of registry COTS software as a supporting tool for the SESAR program

The experience with OGC Catalog Service technology, including but not limited to the experience from previous OGC IPs such as OWS-8, may provide useful input for the work performed by SESAR Project 08.03.02, in particular the SWIM Registry Demonstrator.

OGC Catalog Services support the discovery and management of metadata on services and data. The representation and efficient management of metadata, especially data provenance, will be investigated in OWS-9 Aviation. Catalog/Registry technology can be a useful asset to support this work.

OWS-9 Requirement

The Aviation Thread of OWS-9 shall advance the interoperability of discovery services and their use to manage metadata about services and data including, but not limited to, data provenance information as well as symbols and styling rules.

More specifically, the Aviation Thread of OWS-9 will:

- Connect the OWS-9 infrastructure to the SESAR Registry Demonstrator. This includes the following tasks:
    - Evaluate whether OGC Catalogue Service standards can meet the SESAR Registry requirements. Document the results, especially which SESAR Registry requirements are not met by OGC Catalogue Service standards.
    - Implement a “SESAR-compliant” OGC CSW-ebRIM Registry, which will be part of the OWS-9 Aviation infrastructure, and document relevant results.
        - The OGC CSW-ebRIM Registry does not need to façade the SESAR Registry Demonstrator. There is no need for direct interaction between the two services in OWS-9. However, an analysis on how the two registries can be integrated (e.g. via federated queries, data replication, external links) shall be performed and documented.
        - Identify and document any potential extension to the OGC Catalogue Service standards to meet SESAR Registry requirements.
    - Perform an analysis of gaps between the SESAR registry and OGC Catalogue Service standard(s). Document the results and recommendations on how to close observed gaps.
    - Analyze potential new requirements to improve SESAR SWIM registries and document the results.
    - Include references to the OWS-9 Aviation web services in the SESAR SWIM Registry Demonstrator and document the list of artifacts registered in the SESAR Registry Demonstrator.
        - OWS-9 Aviation Web Service descriptions can be inserted at the SESAR Registry Demonstrator manually and via a WSDL import functionality.
        - This work will enable users to discover the web services from OWS-9 Aviation via the SESAR registry.
- Enable the management and discovery of symbols and styling rules through the OGC CSW-ebRIM Registry in support of the portrayal work that is done in OWS-9 Aviation.
    - Results from previous OGC IPs (such as OWS-8) regarding the application of the OGC CSW-ebRIM Registry in portrayal use cases shall be leveraged.
- Identify how OGC Catalogue services can support the efficient management of metadata, especially data provenance, in the Aviation Architecture.
    - Note: this forms the link to the requirements Mature metadata use and Develop interoperable data transmission to aircraft management in sections 4.2.2.2 and 4.2.2.3, more specifically with the data provenance aspects that they are concerned with.
- Document potential enhancements and issues that were identified by the OWS-9 Aviation participants during the realization of this requirement in change requests against relevant OGC documents, especially Standard and Best Practice documents.

4.2.2.5 Advance interoperable styling and portrayal

References

- Note: to access these SESAR references follow the instructions in Section 4.2.1.
    - SESAR 13.2.2 D01 OSED Step 1 (Digital NOTAM & Digital Integrated Briefing – Baseline Requirement)

  - SESAR 13.2.2 D01 examples of ePIB prototypes
- Digital NOTAM Event Specification v1.0 (available at http://www.aixm.aero/public/standard_page/digital_notam_specifications.html)
- OWS-8 Engineering Report - Guidelines for International Civil Aviation Organization (ICAO) portrayal using SLD/SE (available on the OGC homepage)
- ICAO Annex 3 to the Convention on International Civil Aviation, Meteorological Service for International Air Navigation, Edition 17, July 2010
- ICAO Annex 4 to the Convention on International Civil Aviation, Aeronautical Charts, Edition 11, July 2009

Background

The SESAR 13.2.2 Project has the goal of applying the SESAR concept of distributed collaborative and service oriented architecture to prototype the future AIM sub-system. The project focuses on the evolution of the EAD elements as e.g. EA INO in respect to the Digital NOTAM and Integrated Digital Briefing. The SESAR deliverable D01 "Digital NOTAM & Digital Integrated Briefing – Baseline Requirements" lists the user requirements for Digital NOTAM & Digital Integrated Briefing applications.

The ePIB, or Digitally Enhanced PIB, is a Pre-Flight Information Bulletin compiled using Digital NOTAM data, which is used to create text and/or graphics that facilitate the understanding of the information by the end user. The ePIB contains in particular the static map of departure/arrival airports and graphical representations of relevant aeronautical and meteorological events that are likely to affect the flight for which the report is intended. An example of such a map is provided below:

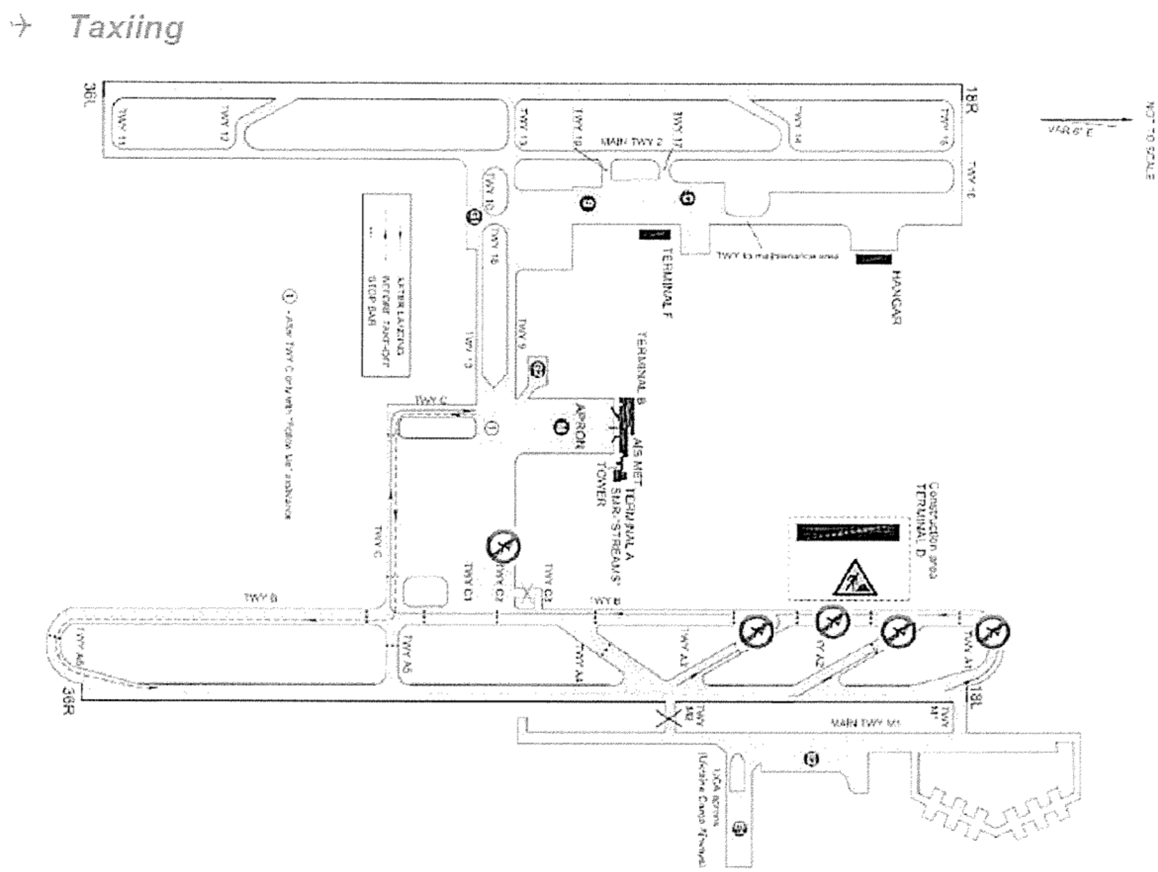

Figure 2 – ePIB map example

OWS-8 Aviation explored the portrayal of AIXM 5.1 and WXXM 1.1 data (including the issues of symbol and styling management) to advance interoperable visualization of aeronautical and meteorological information:

- Exploring multiple style development for AIXM and WXXM data
- Experimenting style selection linked to modeled user needs
- Drafting potential ICAO guidance for SLD and symbol libraries based on ICAO Annexes 3 and 4.

An Aeronautical Information Working Group will be formed in 2012 within the SAE G-10 Aerospace Behavioral Engineering Technology Committee. This group will establish recommended practices with regards to the graphical display of NOTAM information on on-board systems (EFB, flight deck navigation displays…).

OWS-9 Requirement

The Aviation Thread of OWS-9 shall set up a Web Services Architecture to enable the retrieval of "fit for purpose" static airport maps in support of ePIB applications.

More specifically, the Aviation Thread of OWS-9 will:

- Set up and document a Web Services Architecture that will enable the retrieval of static airport maps by a client application to be included in an ePIB.
    - The query made by the client will consist of the identifier of the airport and particular types of aeronautical and meteorological events that should be retrieved.
    - The query workflow shall include some registry look up in order to identify the right services that can deliver the requested data.
    - The static maps shall include as a minimum the graphical representations of the chosen airport and of the relevant aeronautical and meteorological events.
- Ensure that the OWS-9 scenario to demonstrate the static airport map retrieval functionality is based on the existing demonstration use cases foreseen by SESAR Project 13.2.2.
- Document these OWS-9 scenarios.
- Base the developments upon OWS-8 results on AIXM/WXXM portrayal.
- Document any new styling guidelines, styling proposals, symbol libraries or extensions of the OGC Symbology Encoding.
- Analyze material produced by the SAE G-10 Aeronautical Information Working Group, especially any proposed digital symbols. Such material should be reused if feasible based upon the point in time during the execution of OWS-9 that the material is published. Analysis results, such as validation results and/or useful recommendations for the SAE G-10 working group should be documented.
- Document potential enhancements and issues that were identified by the OWS-9 Aviation participants during the realization of this requirement in change requests against relevant OGC documents, especially Standard and Best Practice documents

4.2.2.6 Integrate geometry processing services

References

- Guidelines for the use of GML for aviation data commonly referred to as "OGC GML guidelines for AIXM 5.1" (available at http://external.opengis.org/twiki_public/AviationDWG/GMLGuidelinesForAIXM)

Background

Web Processing Services (WPS) encapsulate a set of specific processing functionality and make it available to clients via the web. Processing tasks common to a given domain can therefore be performed by a dedicated and re-usable component. This approach offers a way to have computing heavy tasks performed by the WPS on behalf of clients that may only have limited resources.

OWS-9 Requirement

The Aviation Thread of OWS-9 shall develop a WPS to support geometry processing required for Aviation operations.

More specifically, the Aviation Thread of OWS-9 will

- Develop a WPS able to determine the spatial relationship of two AIXM 5.1 geometries.
    - Determining that two geometries cross each other can for example be useful to check if an AIXM route crosses a given airspace.

- Develop a WPS able to calculate the intersection between two AIXM geometries.
    - This can be useful for instance to unambiguously retrieve the coordinates of a waypoint defined as the intersection of two place/bearing, or as a place/bearing/distance. This kind of information, if computed unambiguously, would typically prove useful when publishing terminal procedures in AIXM.
    - The process inputs shall be AIXM / GML geometries with the assumption that they are encoded according to the OGC GML guidelines for AIXM 5.1.
        - Note: it is not required that process inputs are general AIXM features. However, this may be a useful extension, especially considering that the use of AIXM features as geometry operands in FES filter expressions will be investigated for the requirement Advance interoperable data retrieval (see section 4.2.2.1).
- Document a description of the two WPSs, especially the processes (inputs, outputs, and computing algorithms) that are realized by these services to enable the required functionality.
- Document any gaps observed between the OWS-9 Aviation requirements for geometry processing and the WPS standard.
- Document potential enhancements and issues that were identified by the OWS-9 Aviation participants during the realization of this requirement in change requests against relevant OGC documents (e.g. the OGC GML guidelines for AIXM 5.1), especially Standard and Best Practice documents.

4.2.3 Advancing system stability and compliancy

4.2.3.1 Investigate system performance and endurance

References

none

Background

The Aviation Architecture for the retrieval of aeronautical feature data via WFS as well as the dissemination of feature updates via the Event Service has matured during past OGC IPs (OWS-6 to OWS-8 as well as the FAA SAA Dissemination Pilot). The focus of these previous initiatives was primarily on the realization of functional requirements. In order to further evaluate the suitability of the proposed architecture for an operational environment, performance, stress and endurance testing is needed.

OWS-9 Requirement

The Aviation Thread of OWS-9 shall investigate, test and document the performance and endurance of the WFS-T and Event Service components within the Aviation Architecture.

More specifically, the Aviation Thread of OWS-9 will:

- Set up an environment for testing the performance and endurance of the WFS-T 2.0 and Event Service, test these two aspects under varying conditions (e.g. number of requests/notifications per second, amount of stored data / subscriptions, complexity of filter statements) and document the test setup and results. More specifically:

- Stress test the Event Service architecture:
  - Simulate and test the publication of [TBD] Digital NOTAMs to be served up to [TBD] potential subscribers every [TBD seconds] over a period of [TBD hours].
  - The exact performance requirements and QoS requirements to be met will be further specified during the OWS-9 Initiation Phase. The tests shall be performed for certain (realistic) constellations (represented by TBDs) including, but not limited to, publication of [10] Digital NOTAMs to be served up to [500] potential subscribers every [30 seconds] over a period of [1 hour].
  - Note: a typical stress situation covered by this kind of stress test is bad weather in the morning and plenty of SNOWTAM messages being issued over a short period.
- Test the endurance of the Event Service architecture:
  - Simulate and test the publication of [TBD] Digital NOTAMs to be served up to [TBD] potential subscribers every [TBD minute] over a period of [TBD hours].
  - The exact performance requirements and QoS requirements to be met will be further specified during the OWS-9 Initiation Phase. The tests shall be performed for certain (realistic) constellations (represented by TBDs) including, but not limited to, publication of [2] Digital NOTAMs to be served up to [500] potential subscribers every [1 minute] over a [24 hours] (this would correspond to today's observed NOTAM issue rate: 1.5 NOTAM issued per minute).
- Test the performance of the WFS-T Architecture:
  - The OWS-9 shall set up an environment for testing a number of scenarios including, but not limited to, the four scenarios listed below, and shall check, for each of these test scenarios, that an answer is received by a client application in less than [TBD] seconds. The tests shall be performed for time constraints (represented by TBD) of including, but not limited to, one second.
    - Scenario 1) Request the gml:identifier, designator, name, position and city served of all airports that start with "ED" in the designator.
    - Scenario 2) Request the complete set of BASELINE, PERMDELTA, TEMPDELTA Timeslices that are valid (valid time is not before or after a given time period) for a specified airport (the request sends the gml:identifier and the time period).
    - Scenario 3) Insert a new BASELINE/PERMDELTA and a correction for a previous BASELINE in the database using WFS-T.
    - Scenario 4) Insert a new TEMPDELTA in the database using WFS-T.
- Note: the filter parameters (in both WFS requests and Event Service subscriptions) can be varied for the performance tests as necessary. The goal is to determine which type of filters/queries can be handled while still matching specific performance figures (that can also be varied).
- The documentation shall at least include:
  - a description of the test environment

    - a description of the method applied to achieve the test results; the method shall be developed collaboratively by all relevant participants, resulting in comparable and unbiased results
    - a detailed list of performance / QoS requirements against which the WFS-T and Event Service architecture was tested
    - the detailed results of the performance evaluation, highlighting in particular the strengths and weaknesses of the specific architecture (WFS-T and Event Service)
    - any potential proposal for architecture design solution(s) delivering desired performance and meeting the QoS requirements (unless already fulfilled by the tested architecture)
- Participants may need to create test data sets for ensuring a representative result of the performance evaluation. These data sets can be created based upon the test/demo data that will be available in OWS-9 Aviation and should reflect realistic use cases.
- Document potential enhancements and issues that were identified by the OWS-9 Aviation participants during the realization of this requirement in change requests against relevant OGC documents, especially Standard and Best Practice documents.

4.2.3.2 Mature system conformance

References

- OWS-8 Guidance for Retrieving AIXM 5.1 data via an OGC WFS 2.0 (available on the Aviation DWG external wiki)
    - Note: a draft OGC Discussion Paper that defines the recommended AIXM 5.1 WFS 2.0 functionality (based upon the results of the OWS-8 report and of the discussions by the Aviation DWG at the OGC TC meeting in Brussels, 2011) is going to be presented at the OGC TC meeting in Austin, March 2012. Work on AIXM 5.1 WFS 2.0 conformance tests should take the contents of this document into account and help to mature it so that it can eventually become an OGC Best Practice.

Background

The OWS Aviation Threads conducted over the past three years have demonstrated the successful use of WFS technology for on demand access to AIXM 5.1 and WXXM 1.1 data. However, a number of outstanding issues have also been identified when it comes to handling the AIXM 5.1 Temporality Model.

OWS-8 has delivered the Engineering Report *Guidance for Retrieving AIXM 5.1 data via an OGC WFS 2.0* which “provides an overview of the operations supported by the WFS 2.0 specification and recommendations for a minimum set of operations and behaviors that an implementation of [AIXM 5.1] WFS 2.0 should support”.

OWS-9 Requirement

The Aviation Thread of OWS-9 shall advance AIXM 5.1 WFS 2.0 compliance, through development of an according test suite and normative documentation.

More specifically, the Aviation Thread of OWS-9 will:

- Develop an AIXM 5.1 WFS 2.0 compliance test suite for the OGC Team Engine.
    - The tests shall be based upon the WFS 2.0 compliance test cases developed in the CITE Thread.
- Develop a normative conformance document for AIXM 5.1 WFS 2.0 developers, in line with the AIXM 5.1 WFS 2.0 compliance test suite.
- Base the developments upon the OWS-8 Guidance for Retrieving AIXM 5.1 data via an OGC WFS 2.0 ER.
- Document potential enhancements and issues that were identified by the OWS-9 Aviation participants during the realization of this requirement in change requests against relevant OGC documents, especially Standard and Best Practice documents.

Note: the creation of the AIXM 5.1 WFS 2.0 compliance test suite may lead to some cross-thread activity with the CITE Thread. There, the creation of a test suite for general WFS 2.0 (including Filter Encoding 2.0) and an according reference implementation will be pursued (See Sections 8.4.6 and 8.4.7)

4.2.4 Advancing modeling support

4.2.4.1 Advance conceptual modeling and mapping tool support

References

- SESAR 08.01.03 D05:
    - AIRM Primer (available at https://portal.opengeospatial.org/files/?artifact_id=47650)
    - AIRM Foundation: Rulebook (available at https://portal.opengeospatial.org/files/?artifact_id=47648)
    - AIRM v2.0 model (available at https://portal.opengeospatial.org/files/?artifact_id=47649)
    - AIRM Public Wiki http://im.eurocontrol.int/wiki/index.php/Main_Page
- WXXM/WXXS version 1.1.3:
    - Model (available at https://portal.opengeospatial.org/files/?artifact_id=47696)
    - XML Schema (available at https://portal.opengeospatial.org/files/?artifact_id=47697)

- Note: to access these SESAR references follow the instructions in Section 4.2.1.
    - Results of SESAR 08.01.06 Study “Lean and mean WXXM”

Background

The ATM Information Reference Model (AIRM) is used as a common reference for the different models that will be developed as part of SESAR. The AIRM represent civil, military and civil-military information constructs relevant to ATM[1]. The AIRM is delivered under the form of a UML Model and provides the shared semantic of all ATM concepts used within SESAR and SWIM. The AIRM can be derived in a number of domain-specific UML and XML physical models meeting the requirements of particular SWIM services and systems. WXXM 1.1.3

[1] Extracted from the SESAR AIRM Primer

(resp. WXXS 1.1.3) is an example of conformant UML (resp. XML) derivation of the AIRM, for the Aviation Meteorology Domain.

SESAR Project 08.01.06 is responsible for the synchronization between the evolutions of the AIRM managed by SESAR and the WXXM developments undertaken jointly by the US FAA and EUROCONTROL. SESAR 08.01.06 conducted a preliminary study which demonstrated the feasibility to derive a "lean and mean" WXXM from the AIRM; this study delivered in particular an initial set of "AIRM to WXXM" mapping rules and a proof-of-concept tool, developed in Java and based on the Sparx EA Java API, able to realize a partial conversion of the AIRM into a WXXM-like model.

A complete set of "AIRM to ISO 19109 Application Schema" mapping rules and according implementation is not yet available. Such functionality would not only enable future derivations of the WXXM from the AIRM in the context of SESAR, but will also enable the creation of "fit for purpose" ISO 19109 Application Schemas for other ATM Domains, in particular those domains that do not yet have an internationally agreed "-XM" format (like AIXM or WXXM).

OWS-9 Requirement

The Aviation Thread of OWS-9 shall develop a tool for mapping an AIRM Information Model package – the "Meteorology" package shall be considered in OWS-9 – into a UML ISO 19109 Application Schema and specific physical encodings, including according mapping rules.

More specifically, the Aviation Thread of OWS-9 will:

- Work on the programmatic derivation of the AIRM "Meteorology" package into a UML ISO 19109 Application Schema. This activity shall consist of:
    - Identifying, developing and documenting a detailed list of "AIRM to UML ISO 19109 Application Schema" mapping rules
    - Providing an implementation of these mapping rules so that an ISO 19109 Application Schema UML model can be programmatically generated from the AIRM Meteorology package.
        - It shall be possible to import the generated model into UML tools including, but not limited to, Sparx EA. A suitable import format would be XMI.
    - Note: EUROCONTROL will provide OWS-9 participants with the results of a preliminary SESAR 08.01.06 study dealing with the synchronization of AIRM & WXXM developments. This study delivered in particular initial sets of "AIRM to WXXM" mapping rules and a proof-of-concept tool, developed in Java and based on the Sparx EA Java API, that is able to realize a partial conversion of the AIRM into a WXXM-like model. The decision to reuse these existing materials or to develop new ones in order to achieve the set of mapping rules and implementation will be up to the OWS-9 participants.
- Investigate and provide a programmatic derivation of WXXM 1.1.3 into a) an XML-based physical model relying on GML 2.1 and b) a JSON-based physical model for Aviation Meteorology, and document the results. More specifically:
    - For both physical models (GML 2.1 and JSON based), assess if the according derivation can already be performed using existing open-source frameworks such as FullMoon or ShapeChange.
        - if so:

            - describe the corresponding configuration of the software framework
            - describe the requirements that shall be satisfied by the input UML model
            - as required, deliver an adaptation of WXXM 1.1.3 that includes the additional information necessary to perform the derivation
        - otherwise:
            - identify and document “WXXM 1.1.3 to GML2.1 / JSON based physical model” derivation rules
            - provide an implementation of these rules
    - create a GML 2.1 / JSON based physical model, validate and document it
        - Note: validation of the physical models through actual exchange of sample datasets via the OWS-9 infrastructure may be but does not need to be realized. The generation of instance document examples is sufficient.
    - Note: the creation of a set of “UML to JSON” encoding rules will also be investigated by the SSI Thread, providing an opportunity for cross-thread activity.
- Document potential enhancements and issues that were identified by the OWS-9 Aviation participants during the realization of this requirement in change requests against relevant OGC documents, especially Standard and Best Practice documents.

Note: the creation of the "UML to JSON" encoding rules is a cross-thread activity with the SSI Thread - see section 6.2.2 for further details.

4.3 Aviation Thread Deliverables

The Deliverables are summarized in the Table with descriptions of the Deliverables in paragraphs following the table.

Table 1 – Aviation Thread Deliverables Summary

1. OWS-9 Aviation Architecture ER – Web Services Architecture
2. OWS-9 Aviation Architecture ER – Portrayal
3. OWS-9 Aviation Architecture ER – WPS
4. OWS-9 Aviation Architecture ER – Registry
5. OWS-9 Aviation Architecture ER – Scenarios
6. OWS-9 Aviation Architecture ER – WFS & Event Service
7. OWS-9 Aviation Architecture ER - Data Transmission Management
8. OWS-9 Aviation Performance Study – ER and Tool
9. OWS-9 Aviation WFS Conformance ER
10. OWS-9 Aviation AIRM to WXXM Derivation ER
11. OWS-9 Aviation Metadata & Provenance ER
12. Change Requests
13. WFS Compliance Test Scripts
14. Web Feature Service - Transactional
15. Feature Portrayal Service
16. Web Processing Service
17. Event Service
18. Registry Service
19. Data Management Service
20. Aviation Client
21. AIRM to WXXM Tool

4.3.1 OWS-9 Aviation Architecture ER – Web Services Architecture

This input to the OWS-9 Aviation Architecture ER will include an overview of the Web Services Architecture established in OWS-9 Aviation (including general workflows as well as descriptions of the service and client components), general lessons learned, a summary of the SWIM compliancy analysis from information management service components (see Figure 15), a summary of the overall accomplishments of OWS-9 Aviation (with input expected to be provided by all participants) and future work items.

The editor of this deliverable shall also be the editor of the whole OWS-9 Aviation Architecture ER and integrate into this document all relevant sections, including those provided by other participants.

This deliverable is related to the following requirement(s):

- Advance interoperable data retrieval
- Mature metadata use
- Develop interoperable data transmission to aircraft management
- Advance discovery interoperability
- Advance interoperable styling and portrayal
- Integrate geometry processing services

4.3.2 OWS-9 Aviation Architecture ER – Portrayal

This input to the OWS-9 Aviation Architecture ER will include issues, lessons learned, recommendations, accomplishments and future work items that result from the OWS-9 Aviation Thread work on the developments for establishing an architecture to enable the retrieval of "fit for purpose" static airport maps in support of ePIB applications.

It will also document the results of and provide input/feedback to the investigations / new developments for a Web Services Architecture that enables the retrieval of static airport maps including, but not limited to: any enhancements to the Feature Portrayal Service, any new styling guidelines, styling proposals, symbol libraries or extensions of the OGC Symbology Encoding and potential use of material provided by the SAE G-10 working group.

This deliverable is related to the following requirement(s):

- Advance interoperable styling and portrayal

4.3.3 OWS-9 Aviation Architecture ER – WPS

This input to the OWS-9 Aviation Architecture ER will include issues, lessons learned, recommendations, accomplishments and future work items that result from the OWS-9 Aviation Thread work on developing a WPS to support geometry processing required for Aviation operations.
It will also document the results of and provide input/feedback to the investigations / developments for the Web Processing Service including, but not limited to: the processes to determine the spatial relationship of AIXM 5.1 geometries and to calculate the intersection between two AIXM geometries (including process inputs, outputs, and specifics of the algorithm). Any identified gaps that prevent the WPS standard to fulfill the OWS-9 Aviation requirements for geometry processing shall also be documented.

This deliverable is related to the following requirement(s):

- Integrate geometry processing services

4.3.4 OWS-9 Aviation Architecture ER – Registry

This input to the OWS-9 Aviation Architecture ER will include issues, lessons learned, recommendations, accomplishments and future work items that result from the OWS-9 Aviation Thread work on connecting the OGC Catalogue Service to the SESAR SWIM Registry Demonstrator.
It will also document the results of and provide input/feedback to the investigations / developments for the OGC CSW-ebRIM Registry including, but not limited to: the efficient

management of styling rules, symbols and metadata (e.g. provenance), inclusion of references to OWS-9 Aviation web services in the SESAR Registry and the implementation of a "SESAR-compliant" OGC CSW-ebRIM Registry.

Furthermore, the participant responsible for this deliverable will investigate various aspects of interoperable discovery including, but not limited to: an analysis whether the OGC Catalogue Service can meet the SESAR Registry requirements (this includes a gap analysis).

This deliverable is related to the following requirement(s):

- Advance discovery interoperability

4.3.5 OWS-9 Aviation Architecture ER – Scenarios

This input to the OWS-9 Aviation Architecture ER will include a detailed description of the scenario(s) developed within the OWS-9 Aviation Thread. The scenario(s) will be used to organize the OWS-9 Aviation developments and as a basis for demonstrating the thread results.

The participant responsible for this deliverable is expected to actively drive the development of the scenario(s), in collaboration with the other OWS-9 Aviation participants. This includes continuous documentation of the scenario(s) as well as revisions based upon recent discussions. The scenario(s) shall include relevant use cases (which are going to be developed / finalized during OWS-9) and be realistic, to the extent feasible.

This deliverable is related to the following requirement(s):

- Advance interoperable data retrieval
- Mature metadata use
- Develop interoperable data transmission to aircraft management
- Advance discovery interoperability
- Advance interoperable styling and portrayal
- Integrate geometry processing services

4.3.6 OWS-9 Aviation Architecture ER – WFS & Event Service

This input to the OWS-9 Aviation Architecture ER will include issues, lessons learned, recommendations, accomplishments and future work items that result from the OWS-9 Aviation Thread work on making aeronautical and weather information accessible via WFS and Event Service.
It will also document the results of and provide input/feedback to the investigations / new developments for WFS & Event Service including, but not limited to: the approach for enabling simple altitude and non-spatial feature queries, data filtering with selective metadata retrieval (documentation to be coordinated with the participant responsible for the OWS-9 Aviation Metadata & Provenance ER, see section 4.3.11), using stored queries / filters at WFS / Event Service, use of specific update intervals for Event Service subscriptions and filtering at WFS using AIXM features as geometry operands.

This deliverable is related to the following requirement(s):

- Advance interoperable data retrieval
- Mature metadata use

4.3.7 OWS-9 Aviation Architecture ER - Data Transmission Management

This input to the OWS-9 Aviation Architecture ER will include issues, lessons learned, recommendations, accomplishments and future work items that result from the OWS-9 Aviation Thread work on an interoperable data transmission management solution.

It will also document the results of and provide input/feedback to the investigations / new developments for the Data Management Service (DMS) including, but not limited to: data communication management (e.g. breaks in communication), message delivery based on priority level, data synchronization between client and dispatcher, efficient data exchanges in an air-to-ground data link (e.g. using compression techniques) – including an analysis of alternatives, enhanced data filtering (including projection and densification as well as the ability to execute common filtering tasks in a simple way) and validation (e.g. determining validity and currency of messages), DMS specific message header/metadata and using metadata to keep track of quality and provenance information at DMS.

Furthermore, the technical architecture for data transmission management will be documented, including the interfaces and workflows of the DMS.

This deliverable is related to the following requirement(s):

- Develop interoperable data transmission to aircraft management
- Advance interoperable data retrieval
- Mature metadata use

4.3.8 OWS-9 Aviation Performance Study – ER and Tool

This deliverable will include development, execution and documentation of performance, stress and endurance tests performed for the WFS-T and Event Service components. Issues, lessons learned, recommendations, accomplishments and future work items that result from this work shall be documented.

This includes, but is not limited to, the setup and documentation of the test environment, development of the performance tool, documentation of the test method(s) and test parameters used, documentation of test data (created if necessary), actual execution of test runs, documentation of performance / QoS requirements that were tested and potential proposals for architecture design solutions that deliver best performance.

This deliverable is related to the following requirement(s):

- Investigate system performance and endurance

4.3.9 OWS-9 Aviation WFS Conformance ER

This Engineering Report will include development / maturation of a normative conformance document for AIXM 5.1 WFS 2.0 developers that is in line with the AIXM 5.1 WFS 2.0 compliance test suite developed in OWS-9 Aviation (see deliverable described in section 4.3.13).

Furthermore, issues, lessons learned, recommendations, accomplishments and future work items that result from this work shall be documented in the WFS Conformance ER. The normative conformance document is a separate document that the participant responsible for this deliverable shall develop/mature accordingly – either directly or by creating a revised word document with all changes tracked (depends on the outcome of the current work in the Aviation DWG – see note in references further above).

This deliverable is related to the following requirement(s):

- Mature system conformance

4.3.10 OWS-9 Aviation AIRM to WXXM Derivation ER

This Engineering Report will include issues, lessons learned, recommendations, accomplishments and future work items that result from the OWS-9 Aviation Thread work on mapping the AIRM to an ISO 19109 Application Schema UML model, with the use case being the AIRM "Meteorology package", and the creation of physical encodings based on GML 2.1 and JSON.

It will document the results of and provide input/feedback to the investigations / new developments for performing the required mapping including, but not limited to: new mapping and encoding rules, a description of the used tool(s) and summary of the tool(s) adaptations and configurations as well as any specific requirements for enabling the mapping and encoding functionality.

This deliverable is related to the following requirement(s):

- Advance conceptual modeling and mapping tool support

4.3.11 OWS-9 Aviation Metadata & Provenance ER

This Engineering Report will include issues, lessons learned, recommendations, accomplishments and future work items that result from the OWS-9 Aviation Thread work on metadata use in OWS-9 Aviation.

It will document the results of and provide input/feedback to the investigations / new developments for data access/provision at WFS / Event Service with selective metadata retrieval. Documentation of data filtering with selective metadata retrieval will be coordinated with the participant responsible for the OWS-9 Aviation Architecture ER – WFS & Event Service deliverable (see section 4.3.6).

Furthermore, the participant responsible for this deliverable will investigate various aspects of metadata use including, but not limited to: the representation, efficient management and maintenance of metadata (e.g. for aeronautical and weather information conforming to the guidance provided by the Aviation DWG but also provenance in general) – also taking into account alternative approaches (including an analysis of their technical feasibility and potential efficiency gain), alignment of metadata guidance provided by the Aviation DWG and NNEW and retrieving ISO 19139 formatted metadata directly from OGC services. The results of this investigation shall be documented in the Metadata & Provenance ER. The participant is the main party responsible to perform this investigation and documentation task, but shall collaborate with other participants – especially coordinating the investigation with the work that is performed in the CCI Thread.

This deliverable is related to the following requirement(s):

- Mature metadata use
- Develop interoperable data transmission to aircraft management

4.3.12 Change Requests

This deliverable covers the documentation of identified potential enhancements and issues in change requests against relevant OGC documents, especially Standard and Best Practice documents.

This deliverable is related to the following requirement(s):

- Advance interoperable data retrieval
- Mature metadata use
- Investigate system performance and endurance
- Develop interoperable data transmission to aircraft management
- Mature system conformance
- Advance discovery interoperability
- Advance interoperable styling and portrayal
- Integrate geometry processing services
- Advance conceptual modeling and mapping tool support

4.3.13 WFS Compliance Test Scripts

The realization of this deliverable will include the development of an (executable) AIXM 5.1 WFS 2.0 compliance test suite for the OGC CITE Team Engine. The developments shall be harmonized and coordinated with the development of the WFS 2.0 compliance test cases which is performed by the CITE Thread. The test suite will be tested against available AIXM 5.1 WFS 2.0 components including, but not limited to, the one(s) within the OWS-9 Aviation Architecture.

The participant responsible for this deliverable shall support the documentation tasks of the deliverable described in section 4.3.9.

This deliverable is related to the following requirement(s):

- Mature system conformance

4.3.14 Web Feature Service - Transactional

The realization of this component deliverable will include the import and provision of aeronautical and weather information (as AIXM and WXXM) for test/demo purposes, the investigation and development of advanced filtering functionality (e.g. altitude queries that take the vertical extent of a feature into account, non-spatial feature queries and AIXM features as geometry operands for spatial filter operators), selective retrieval of metadata, support for stored queries and an analysis of SWIM compliancy (as input to the summary which will be incorporated in the Web Services Architecture ER).

Note: the component will be used for performance testing.

Documentation of the component shall be provided including, but not limited to, appropriate documentation of the requests that were used in support of the demo scenarios to retrieve data.

The participant responsible for this deliverable shall support the documentation tasks of the deliverable described in section 4.3.6.

This deliverable is related to the following requirement(s):

- Advance interoperable data retrieval
- Mature metadata use
- Investigate system performance and endurance

4.3.15 Feature Portrayal Service

The realization of this component deliverable will include the realization of an FPS for portraying AIXM and Weather data retrieved from WFS with the ultimate purpose of creating static airport maps in support of ePIB applications, application of styling rules and symbols (potentially also new symbols developed by the SAE G-10 working group) retrieved upon request from an OGC CSW-ebRIM Registry, an analysis of any material made available by SAE G-10 and an analysis of SWIM compliancy (as input to the summary which will be incorporated in the Web Services Architecture ER).

The participant responsible for this deliverable shall support the documentation tasks of the deliverable described in section 4.3.2.

This deliverable is related to the following requirement(s):

- Advance interoperable styling and portrayal

4.3.16 Web Processing Service

The realization of this component deliverable will include implementation of a WPS to support geometry processing required for Aviation operations and an analysis of SWIM compliancy (as input to the summary which will be incorporated in the Web Services Architecture ER).

The participant responsible for this deliverable shall support the documentation tasks of the deliverable described in section 4.3.3.

This deliverable is related to the following requirement(s):

- Integrate geometry processing services

4.3.17 Event Service

The realization of this component deliverable will include the provision of aeronautical and weather information updates encoded as AIXM, Digital NOTAM and WXXM for test/demo purposes as well as the investigation and development of advanced filtering functionality (e.g. altitude queries that take the vertical extent of a feature into account as well as non-spatial feature queries), selective provision of metadata, support for stored filters, support of update intervals for subscriptions and an analysis of SWIM compliancy (as input to the summary which will be incorporated in the Web Services Architecture ER).

Note: the component will be used for performance testing.

Documentation of the component shall be provided including, but not limited to, appropriate documentation of the events and subscriptions that were used in support of the demo scenarios.

The participant responsible for this deliverable shall support the documentation tasks of the deliverable described in section 4.3.6.

This deliverable is related to the following requirement(s):

- Advance interoperable data retrieval
- Mature metadata use
- Investigate system performance and endurance

4.3.18 Registry Service

The realization of this component deliverable will include an implementation of the OGC CSW-ebRIM Registry, connecting the OWS-9 Aviation Architecture to the SESAR Registry Demonstrator (includes registering OWS-9 Aviation web services in the SESAR Registry and analyzing whether the OGC Catalog Service can meet the SESAR Registry requirements) and an analysis of SWIM compliancy (as input to the summary which will be incorporated in the Web Services Architecture ER). It shall also support the management of metadata including, but not limited to: styling rules and symbols as well as other metadata (e.g. quality and provenance of aeronautical and weather information). The participant responsible for this deliverable shall perform according data loading tasks, as required.

The participant responsible for this deliverable shall support the documentation tasks of the deliverable described in section 4.3.4.

This deliverable is related to the following requirement(s):

- Advance discovery interoperability
- Mature metadata use
- Develop interoperable data transmission to aircraft management
- Advance interoperable styling and portrayal

4.3.19 Data Management Service

The realization of this component deliverable will include the realization of efficient data transmission methods in air-to-ground communications. This includes, but is not limited to, the investigation and development of functionality that supports: data communication management (e.g. breaks in communication), message delivery based on priority level, data synchronization between client and dispatcher, efficient data exchanges in an air-to-ground data link (e.g. using compression techniques), enhanced data filtering (including projection and densification as well as the ability to execute common filtering tasks in a simple way) and validation (e.g. determining validity and currency of messages), DMS specific message header/metadata and the recording and management of metadata to keep track of quality and provenance information at DMS.

An analysis of alternative ways to realize efficient data exchanges in an air-to-ground link should be performed together with the participant responsible for the deliverable described in section 4.3.7. In general, the participant responsible for the Data Management Service deliverable shall support the documentation tasks of the deliverable described in section 4.3.7.

The approach for representing and managing metadata at DMS shall be part of (and thus in line with) the more general investigation and developments for metadata use in OWS-9 Aviation and the OWS-9 CCI Semantic Mediation / Provenance threads.

This deliverable is related to the following requirement(s):

- Develop interoperable data transmission to aircraft management
- Mature metadata use

4.3.20 Aviation Client

The realization of this component deliverable will include interfacing with all OWS-9 Aviation service components, for testing and demonstrating the relevant service functionality. The client shall support the OWS-9 Aviation demonstration(s) based upon the OWS-9 Aviation scenario(s). Emphasis is on supporting and demonstrating new client and service functionality developed by the participants in the OWS-9 Aviation Thread.

This deliverable is related to the following requirement(s):

- Advance interoperable data retrieval
- Mature metadata use
- Develop interoperable data transmission to aircraft management
- Advance discovery interoperability
- Advance interoperable styling and portrayal
- Integrate geometry processing services

4.3.21 AIRM to WXXM Tool

The realization of this deliverable will include the implementation/adaptation/configuration of (possibly existing) software to perform the mapping of AIRM models to ISO 19109 Application Schema UML models – based upon the AIRM “Meteorology package” – and subsequent encoding into physical models based upon GML 2.1 and JSON. Required mapping and encoding rules will be developed, including the identification of any specific requirements for enabling the mapping and encoding functionality.

The participant responsible for this deliverable shall support the documentation tasks of the deliverable described in section 4.3.10.

This deliverable is related to the following requirement(s):

- Advance conceptual modeling and mapping tool support

4.4 Aviation Enterprise Viewpoint

According to the FAA website, the air transportation system is stretched thin with forecasts indicating increases in passenger demand ranging from a factor of two to three by 2025. The current system is already straining with ever-increasing levels of congestion, declining on-time arrivals, increasing delays (and customer frustration) as well as increasing costs and environmental impacts. At the same time, according to EUROCONTROL, the European Airspace is fragmented and will become more and more congested, as traffic is forecast to grow steadily over the next 15 years. The legacy Air navigation services and their supporting systems are not fully integrated and are based on technologies that are already running at maximum. AirServices Australia (ASA) has acknowledged similar issues in the Commonwealth, as have other nations in the Pacific Rim and in economically emerging nations. In order to accommodate future Air Traffic needs, a “paradigm shift”, supported by state-of-the-art and innovative technologies, is required.

To realize this paradigm shift (Figure 3) the Aviation industry is working on a framework built extensively on standards, digital data exchange and process automation.

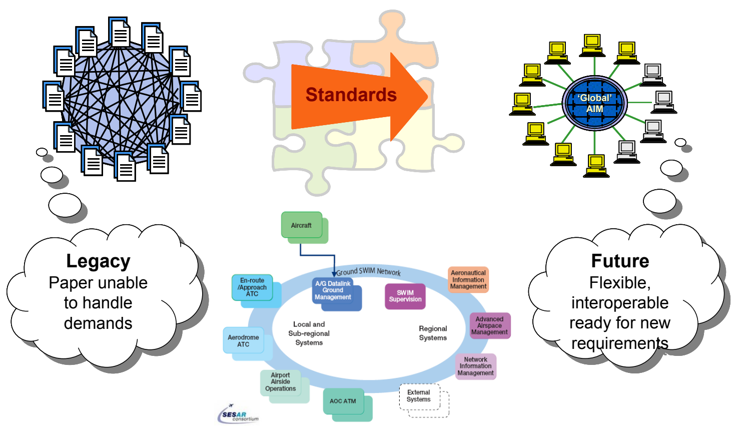

Figure 3 – Towards a New Aeronautical Information Management Paradigm

At the heart of this new AIM paradigm is the Aeronautical Information Exchange Model (AIXM) (Figure 4) AIXM is a comprehensive aeronautical information content and exchange model developed by EUROCONTROL in the 1990s and then considerably expanded and modernized through the collaboration of the FAA, NGA and others (Figure 5).

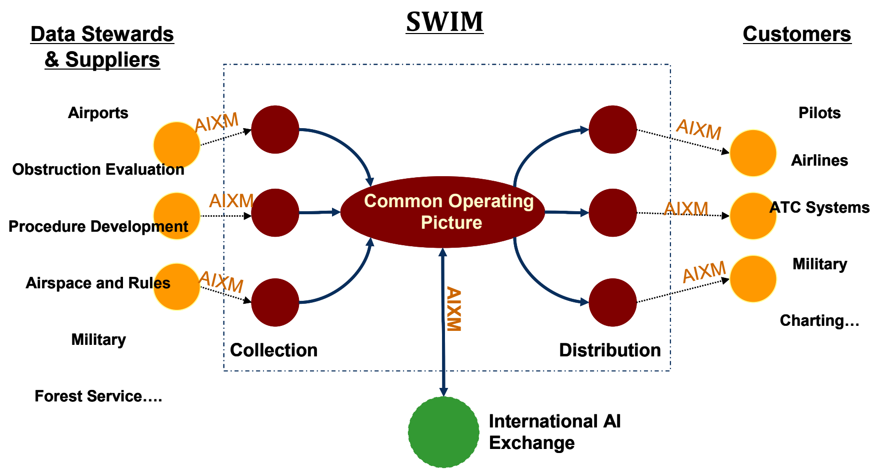

Figure 4 – AIXM in Support of New AIM Paradigm

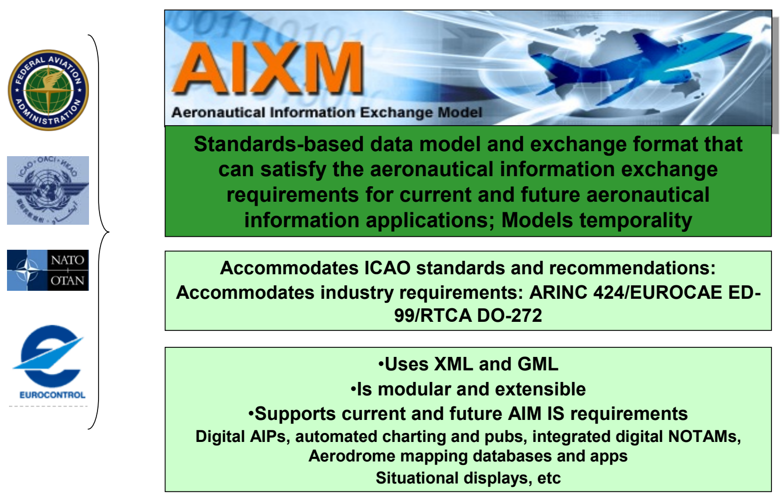

Figure 5 – AIXM Overview

The FAA is using AIXM in its Next Generation Air Transport System (NextGen) and the net-centric System Wide Information Management (SWIM) program, described in the next sections. Similarly, EUROCONTROL is using AIXM in the development of the Single European Sky initiative, also described in this section.

4.4.1 FAA Next Generation Air Transport System (NextGen)

NextGen encompasses the operational and technological changes needed to increase the US National Airspace System (NAS) capacity, to meet future demands and avoid gridlock in the sky and in the airports (http://www.faa.gov/regulations_policies/reauthorization/). NextGen requires improved common situational awareness, integration of air traffic management and control, consistent use of weather data and forecasts for flight planning and better coordination of responses to adverse conditions. The FAA is a key participant in the US Joint Program Development Office (JPDO) which is a multi-agency initiative overseeing the evolution of NextGen concepts.

AIXM provides the foundation for NextGen (Figure 6). Upon that foundation rests many of the next generation operational improvements including on-demand NAS information, continuous flight day evaluations, trajectory-based management, constrained flight planning, collaborative air traffic management and reduced weather impacts amongst others.

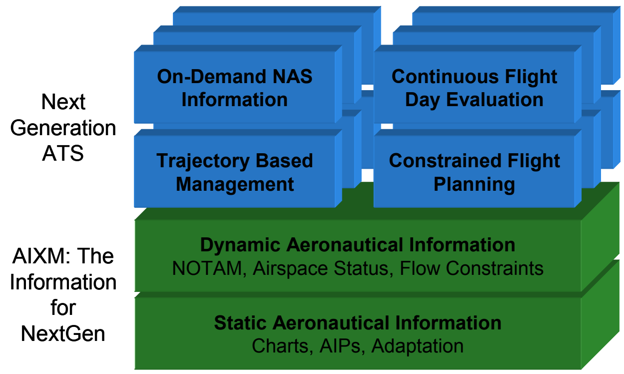

Figure 6 –AIXM as the Foundation for NextGen

A key element of NextGen is the NextGen Network Enabled Weather (NNEW), which will serve as the core of the NextGen weather support services and provide a common weather picture across the NAS. The goal of NNEW (in conjunction with other NextGen technologies) is to cut weather-related delays at least in half since currently seventy percent of NAS delays are attributed to weather every year. NNEW is focused on the dissemination of weather data to meet the NextGen goals. NNEW is being built upon a Service Oriented Architecture (SOA) to enable effective opportunities for data dissemination. It enables integration of information from weather sources into all applicable NextGen decision support systems, and fuses weather observations into a common virtual, continuously updated weather information data set available to all network users. More information on NNEW can be found on the NNEW Dissemination home page at https://wiki.ucar.edu/display/NNEWD/The+NNEW+Wiki.

4.4.2 Single European Sky ATM Research (SESAR)

The European Airspace is fragmented and will become more and more congested, as traffic is forecast to grow steadily over the next 15 years. The legacy Air navigation services and their supporting systems are not fully integrated and are based on technologies that are already running at maximum. In order to accommodate future Air Traffic needs, a "paradigm shift", supported by state-of-the-art and innovative technologies, is required. That paradigm shift is realized via the Single European Sky ATM Research (SESAR) initiative. For the first time in European ATM history, an ATM improvement programme is involving the Aviation Players (civil and military, legislators, industry, operators, users, ground and airborne) for defining, committing to and implementing a pan-European programme, and to support the Single European Sky legislation.

SESAR is a Joint European Commission/EUROCONTROL initiative (currently in the Development phase according to Figure 7) that targets the elimination of the fragmented approach to ATM, the transformation of the European ATM system and the synchronization of plans and actions of the different partners and federated resources. The Development Phase (2008-2016) will produce the new generation of technological systems and components as defined in the Definition Phase. According to the SESAR Master Plan, interoperability is key to the success of SESAR. Consequently, the Development Phase will also deliver the technical ground for defining internationally agreed standards and norms that can be leveraged in SESAR. A standardization roadmap will be developed and kept up to date as a specific chapter of the ATM Master Plan. More information on SESAR can be found at http://www.eurocontrol.int/sesar/public/subsite_homepage/homepage.html.

Figure 7 – SESAR Phases

The SESAR Master Plan also states "European ATM should be considered as a virtual single enterprise in which constituent parts work together in a networked (net-centric) service-based operation". The goal is to achieve that using an overall information architecture based on the concept of SWIM (Section 4.4.3). The SWIM concept is required for building the net-centric environment and enterprise architecture (a light-weight, massively distributed, horizontally applied architecture that distributes components and/or services across an enterprise's information value chain using internet technologies and other network protocols as the principal mechanism for supporting the distribution and processing of information services.

4.4.3 System Wide Information Management (SWIM)

The FAA SWIM Program (http://www.swim.gov) is an enterprise-wide program that will enable reusable, loosely coupled interfaces; reduce time and complexity for building new applications and interfacing existing applications; and provide common shared services for information management replacing costly redundancies. The SWIM Program will provide a secure NAS-wide information web to connect FAA systems to one another, and to other global SWIM-like systems, as well as enable interaction with other members of the decision-making community. FAA SWIM will provide policies, standards, and core infrastructure to support data management, based on existing systems and networks to the extent practicable, and using proven technologies to reduce cost and risk.

In SESAR, the SWIM Thread work packages (WP) 8 and WP14 are focused on the evolutions towards the System Wide Information Management. The objective of WP 8 is to establish the framework which defines seamless information interchange between all providers and users of shared ATM information, so as to enable the assembly of the best possible integrated 4D picture of the past, present and (planned) future state of the ATM situation. The framework put in place by WP8 essentially defines (i) the commonly shared ATM information concepts as represented by the ATM Information Reference Model (AIRM), (ii) the commonly shared ATM information services as represented by the ATM Information Services Reference Model (ISRM).

The SWIM technical architecture is described in SESAR's Work Package 14. In short, for supporting seamless information interchange between all providers and users of shared ATM information, the SESAR SWIM technical architecture provides

- A set of technical services necessary to support interactions between systems; those services will be selected from the field-proven solutions in the market;
- Access to the SWIM physical network.

Further information on SESAR WP8 and WP14, visit http://www.eurocontrol.int/articles/system-wide-information-management

4.4.4 Aircraft Access to SWIM (AAtS)

The Aircraft Access to SWIM (AAtS) mission is to enable the connection between aircraft and the U.S National Airspace System (NAS) Service-Oriented Architecture (SOA) platform being implemented by System-Wide Information Management environment (SWIM). This connection will provide NAS operational data intended to support uses that affect the efficiency of strategic and tactical traffic management operations up to, but not including, uses that directly affect the trajectory of the aircraft. The FAA NextGen Implementation Plan[2] has defined the NextGen System Development Project *New ATM Requirements* which describes a need for an airborne component of the SWIM SOA. AAtS is the effort to define how to provide a connection from SWIM SOA shared resources to an aircraft whether it is on the ground or in the air. The AAtS initiative does not intend to implement a specific infrastructure to create the actual link to the aircraft but will define a set of operational and technical requirements that will be used to drive that infrastructure.

Aircraft Access to SWIM will provide aircraft with a means to connect to a common collection of aeronautical services provided from multiple sources including the FAA, DHS, airports, and other information sources. Its goal is to provide a globally interoperable extension of the NAS Service-Oriented Architecture to aircraft allowing a common shared aviation information environment. Operators employing the AAtS connection will use air/ground network services providers' infrastructure to exchange data between the aircraft and the NAS.

AAtS objectives include:

- Create a common decision-making framework between aircraft and the NAS.
- Provide ground to air and air to ground data exchanges between aircraft and NAS services.
- Provide aeronautical, weather, and operational flight information to flight crews and operators.
- Support global interoperability between AAtS users and other Air Navigation Service Providers.

Figure 8 illustrates a notional AAtS Architecture. In the DMS Tier:

- Communications with the aircraft are managed.
- The data is filtered based on the configuration profile established by the dispatcher and the EFB. The aircrew and the Dispatcher have the ability to manage data filtering configurations in the DMS Tier
- The data is validated based on the business rules cited in the AAtS Mid-Term architecture Systems Rules Model (see Section 10)
- Data provenance, traceability, and quality are maintained by the DMS.
- The data is transmitted to the EFB via a wireless data link and to the Dispatcher using AIXM / WXXM information exchanges.

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[2] *NextGen Implementation Plan*, FAA, March 2011, p.68.

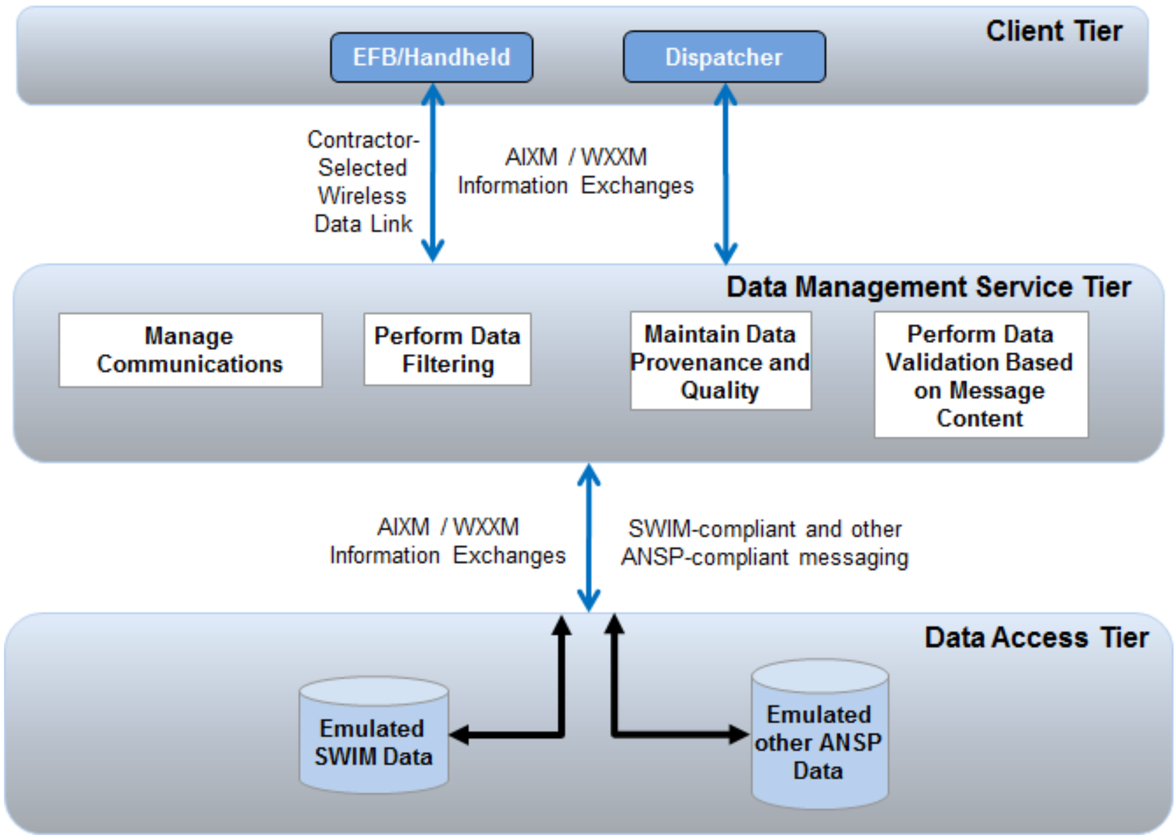

Figure 8 – Notional AAtS Architecture

4.4.5 Aviation Thread Scenarios and Use Cases

The Aviation Thread scenarios provide a fictitious, but realistic context for a demonstration of the functionality that will be developed in the Aviation Thread of OWS-9, and for the interaction with other OWS components. The scenarios are intended to prompt the exercising of interfaces, components, tools and services as well as the use of encodings that will be developed or enhanced within OWS-9. This includes exercising a variety of web services utilizing AIXM and WXXM encodings and demonstrating data transmission management functionality.

Within the OWS-9 Aviation thread, the scenarios will revolve around the following theme(s):

- Continued support for dispatch and planning activities started in OWS-7, including efficient communication between clients located on an aircraft and the information management services
    - This will include aspects (especially creation of airport maps for ePIB) of the *Digital NOTAM Usage* scenario, see section 5.2 in SESAR document 13.2.2 D01 OSED Step 1 (Digital NOTAM & Digital Integrated Briefing – Baseline Requirement); to access the document, follow the instructions in 4.2.1

The following scenario(s) and use cases are subject to change as determined by various factors, most notably availability of AIXM and weather data. The details and scope of the scenarios and use cases will be discussed at the initiative kickoff. The scenarios and use cases will be revised and enhanced during OWS-9, as required.

4.4.5.1 Dispatch and Planning on the Ground and during Flight Scenario

The following scenario describes a relatively uneventful flight that uses weather and aeronautical information to support decisions about potential alternate airports while en route. The aircraft is a business jet with the pilot satisfying the roles of both Pilot-in-Command and Dispatcher. The scenario extends the dispatch and planning scenarios from previous testbeds in that aspects of managing data transmissions via wireless data link are involved. This requires efficient use of the available network resources, as well as reliable communication when network disruptions or switches are encountered.

Note: for OWS-9 Aviation tests and demonstrations, the connection of clients via wireless data link to the information management services may be simulated. For example, the change of communication network from Wi-Fi to satellite link results in an IP change which should be handled by the data transmission management functionality provided by the client and Data Management Service (DMS).

Phase	Activities
Pre-Departure Data Exchange (Flight Planning)	**ZZ Flight uvw** is scheduled to depart from Airport **TBD1** for Airport **TBD2**. After the pilot receives the flight briefing from flight operations, a ground delay due to adverse weather or other event (e.g. approaching wildfire) on the first segment of the route is put into effect for **ZZ Flight uvw** which remains at the gate. The pilot enters the aircraft three hour after his briefing and configures the EFB device for the upcoming flight which will trigger the retrieval of relevant information for any updates to aeronautical information for **TBD1**, **TBD2,** for **TBD3** (an alternate airport close to the filed route of flight to be used in an emergency occurring during flight prior to the equal time point (ETP)), and for **TBD4** (an alternate airport to be used in the event that a landing at **TBD2** cannot be made). It is assumed that, while on the ground, the aircraft is connected to a high-speed TCP/IP network. For the purpose of the test bed, the public Internet will be used. Shortly after configuring the EFB, updated aeronautical information for **TBD3** is displayed on the EFB indicating that **TBD3** is closed due to bad weather or other event (e.g. approaching wildfire). The update information is superimposed on the display of the route as a highlight at the affected location. The highlight is expandable to show the update in either text or graphic format. The pilot enters a request on the EFB for a convective weather layer, turbulence layer and lightning layer in an area that will affect the planned route and altitude of flight based on the location of the aircraft over time as calculated by the planned speed of the aircraft and the estimated departure time (ETD). The requested information is received and displayed on the EFB with the forecast weather events superimposed on the map. The display shows a strong weather system that will affect the filed route within the times specified. The pilot requests Air Traffic Control (ATC) (by

Phase	Activities
	voice) for a new route and is given an amended route to **TBD2** that will avoid the weather system. The pilot enters a request on the EFB to retrieve and display information on airports within 100 nautical miles of the amended route of flight at which his aircraft will be able to land in the event of an emergency occurring while the aircraft is prior to the ETP from **TBD1**. The location of Airport **TBD5** is returned and is displayed on the EFB, superimposed on a visualization of the amended route of flight. The pilot enters a request for detailed aeronautical information, including approaches, on **TBD5**. The information is superimposed on the display of the route as a highlight at the affected location. The highlight is expandable to show the update in either text or graphic format. The EFB calculates the time of his closest approach to **TBD5** and requests forecast weather information for **TBD5** for a possible landing at that time. The requested information is displayed on the EFB with the forecast weather events superimposed on the map. The display shows no significant weather forecast for **TBD5** so the pilot configures the EFB to automatically retrieve and display any updates to aeronautical information for **TBD5** and cancels the retrieval of data for **TBD3**. However, the pilot configures the EFB to accept update notifications for **TBD3** that change its closed/open status. Shortly after this, TBD3 is re-opened.
Transition to a different data link provider	The ground controller at **TBD1** airport clears **Flight uvw** to taxi for departure. As the aircraft taxis, the EFB may connect to another data link provider with wider coverage. After take-off, the EFB connects to an appropriate wide-coverage data link provider and the EFB maintains its requests for automatic feeds of any updates to aeronautical information or weather information for **TBD2, TBD4** and **TBD5** seamlessly.
En Route Data Exchange	During the flight, whenever update information is available for these airports, an update notification is displayed on the EFB.
Transition from departure data source to destination data source	**Flight uvw** transitions from the departure ANSP data source to the arrival ANSP data source and the EFB maintains its requests for automatic feeds of any updates to aeronautical information for **TBD2 and TBD4** seamlessly.
Arrival Planning Data Exchange	An update notification is received for the destination airport, TBD2, and the pilot requests display of the update information for that airport from the arrival ANSP data source, which is then displayed on the EFB. The update information is superimposed on the display of the route as a highlight at the affected location. The highlight is expandable to show the update in either text or graphic format. The updated information displayed for **TBD2** shows that all the runways at **TBD2** are closed. (Fires in close proximity to the airport are producing

Phase	Activities
	extensive smoke over the airport.) The pilot obtains permission from ATC to divert to **TBD4**. During this time, no updates had been received for TBD4. The pilot configures the EFB to display relevant weather in effect for **TBD4** which triggers a request for an automatic feed to the EFB of pertinent weather data**.** The responses to this request are displayed on the EFB as the flight continues and indicates that there is no significant weather at **TBD4**. **ZZ** Flight **uvw** then lands without incident**.**

4.4.5.2 Altitude Query Use Cases

Use Case #1

Airspace features containing an upper and lower altitude are spatially filtered (by WFS / Event Service). The service provides Airspace features that fall within both the 2-D bounding box and within the upper and lower altitude. This includes interpreting the Airspace altitudes of 'GND' and 'UNL'.

Use Case #2

Airspace features containing an upper and lower altitude are spatially filtered (by WFS / Event Service). The base geometry of an Airspace feature matches the filter, but it contains an exclusion area. When this area is excluded from the base area, the geometry of the Airspace feature no longer matches the filter. The service should not provide the Airspace feature.

Example:

The base of an airspace has a lower altitude of 200 feet and an upper altitude of 17999 feet. There is an exclusion to the Airspace for above 5000 feet for a portion of the shape. The spatial filter only overlaps with the excluded shape and is for Airspaces above 6000 feet. The service should not provide the airspace.

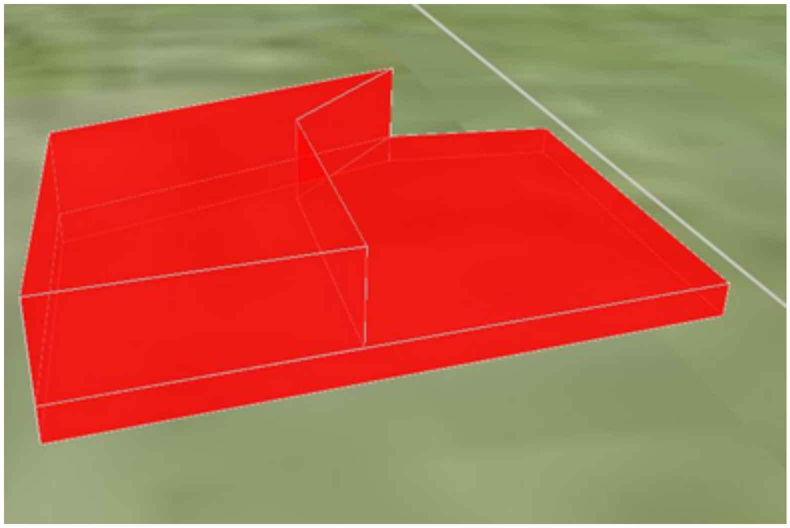

Figure 9 – Example Airspace for Altitude Query Use Case #2

Use Case #3

Airspace features containing an upper and lower altitude are spatially filtered (by WFS / Event Service). The base geometry of an Airspace feature does not match the filter, but it contains a union area. When this area is added to the base area, the geometry of the Airspace feature matches the filter. The service should provide the Airspace.

Example:

The base of an airspace has a lower altitude of 200 feet and an upper altitude of 5000 feet. There is a union to the airspace for above 5000 feet for a portion of the shape. The spatial filter overlaps the shape of the airspace, but is for airspace above 8000 feet. The service should provide the whole airspace.

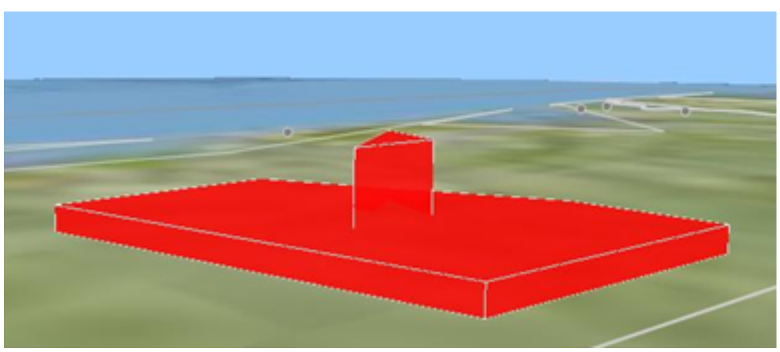

Figure 10 – Example Airspace for Altitude Query Use Case #3

4.4.5.3 Non-Spatial Feature Query Use Case

A user spatially filters AirportHeliport features and their associated Runway features. Runway features have no spatial component within the feature itself, but related RunwayElement and RunwayDirection features that reference the Runway feature contain the geometries of the Runway. These underlying geometries are provided (in the WFS response / Event Service message) and displayed along with the Runway features.

Note: other examples of such non-spatial features are Taxiway and Apron features with geometries contained in TaxiwayElement and ApronElement features, respectively.

4.5 Aviation Information Viewpoint

The Information Viewpoint describes the information models and encodings that will make up the content of the services and exchanges to be extended or developed to support the Aviation thread activities.

4.5.1 AIXM

Relevant Specification and Documents*:*

- *AIXM 5.1* http://www.aixm.aero/public/standard_page/download.html

AIXM 5 takes advantage of existing and emerging information engineering standards and supports current and future aeronautical information system requirements. The major tenets are

- An exhaustive temporality model describing when features are valid and how feature properties change over time. The Temporality model also covers modeling the temporary information contained in NOTAMs (Notice to Airmen),
- Alignment with ISO standards for geospatial information (Figure 11) including the use of the Geography Markup Language (GML 3.2),
- Support for the latest ICAO and user requirements for aeronautical data including obstacles, terminal procedures and airport mapping databases,
- Modularity and extensibility to support current and future aeronautical information messaging requirements and additional data attributing requirements.

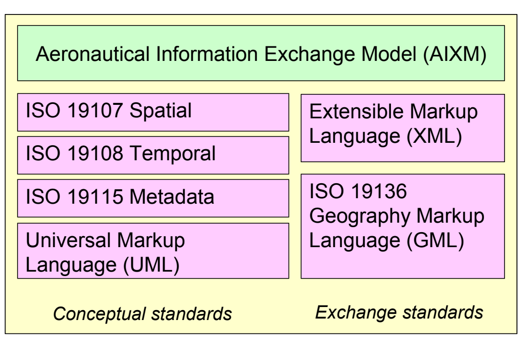

Figure 11 – AIXM Based on International Standards

4.5.2 Digital NOTAM Event Specification

Relevant Specification and Documents:

- *Digital NOTAM Event Specification - version 1.0*
  http://www.aixm.aero/public/standard_page/digital_notam_specifications.html

The Digital NOTAM Event Specification defines the rules for harmonised encoding as AIXM data sets (version 5.1 or later) of the information currently published through NOTAM messages. The document is intended primarily to system developers, as most of these rules will have to be translated into computer code that results in database structures, human-machine interfaces, data validation rules, etc. However, the document is developed with significant input from operational experts, in order to capture all the rules and requirements that will guarantee safe, efficient and reliable Digital NOTAM operations.

The main goal of the document is to enable the interoperability of the different systems that produce, transform, transmit and consume Digital NOTAM data, as part of the digital aeronautical information is general. The application of common rules is also expected to reduce the cost of the implementations because it minimizes the need for mapping and adaptation of the data coming from different sources.

4.5.3 WXXM

Relevant Specifications:

- *Weather Information Exchange Model WXXM on*
  http://www.wxxm.aero/public/subsite_homepage/homepage.html
- *WXXM model and schema, published together with this RFQ*

Note: WXXM version 1.1.3 will be used in OWS-9 Aviation. This is the latest release of WXXM (created by EUROCONTROL) which was developed to capture additional information about volcanic ash mass concentration. WXXM 1.1.3 primarily adds new elements and thus should be compatible with WXXM 1.1.1.

The Weather Information Exchange Models and Schema (WXCM-WXXM-WXXS) are designed to enable a platform independent, harmonized and interoperable meteorological information exchange covering all the needs of the air transport industry.

WXXM uses GML tailored to the specific requirements for aeronautical meteorology and is based on the OGC Observation and Measurement Model (O&M) (http://www.opengeospatial.org/standards/om).

4.5.4 GML and AIXM GML Profile

Relevant Specification and Documents:

- *OpenGIS® Geography Markup Language (GML) Encoding Specification 3.2.1*
  http://portal.opengeospatial.org/files/?artifact_id=20509

- *GML Guidelines for AIXM 5.1 – available on OGC Aviation Domain Working Group (DWG) public wiki page* *http://external.opengeospatial.org/twiki_public/AviationDWG/GMLGuidelinesForAIXM*

The Geography Markup Language (GML) is an XML encoding for the transport and storage of geographic information, including both the geometry and properties of geographic features. Both AIXM and WXXM are based on GML.

The Aviation DWG of OGC is in the process of developing an AIXM 5.1 GML profile. The community acknowledged the need for such profile because the ISO 19107 spatial schema (implemented by GML) is complex, and contains an extensive list of geometries, geometric properties and operations – many of which are not necessary for aeronautical information applications. In addition, the ISO 19107 contains a complicated 3D geometry model that is not suitable for AIXM either.

The GML profile for AIXM currently under development identifies a selection of GML features that all AIXM implementers need to eventually support.

4.5.5 Deflate

Relevant Specification and Documents:

- *DEFLATE Compressed Data Format Specification version 1.3* http://www.ietf.org/rfc/rfc1951.txt

- *OWS-9 AIXM 5.1 Compression Benchmarking ER* https://portal.opengeospatial.org/files/?artifact_id=46394

Deflate is a lossless data compression algorithm that uses a combination of the LZ77 algorithm and Huffman coding. It is specified in IETF RFC 1951. Deflate is used in gzip compressed files and PNG image files in addition to the ZIP file format.

Deflate has been investigated and tested in the compression benchmarking study of OWS-9.

4.5.6 Fast Infoset

Relevant Specification and Documents:

- *X.891: Information technology - Generic applications of ASN.1: Fast infoset – 2007-01-30* http://www.itu.int/rec/dologin_pub.asp?lang=e&id=T-REC-X.891-200505-I!!PDF-E&type=items
- *W3C XML Information Set* (second edition) http://www.w3.org/TR/xml-infoset/

Fast Infoset is an international standard that specifies a binary format for XML infosets which is an efficient alternative to XML. An instance of this binary format is called a fast infoset document. Fast infoset documents are analogous to XML documents. Each has a physical form and an XML infoset. Fast infoset documents have shown to be faster to serialize and parse, and smaller in size, than the equivalent XML documents. Thus, fast infoset documents may be used whenever the size and processing time of XML documents is an issue.

The binary format is optimized to balance the needs of both document size and processing time. Fast infoset documents are useful in a number of domains from bandwidth- and resource-constrained mobile devices to high-bandwidth high-throughput systems.

Fast infoset has been investigated and tested in the compression benchmarking study of OWS-9.

4.5.7 ISO 19115 / ISO 19139 Metadata Model / XML Schema Implementation and AIXM Metadata Profile

Relevant Specification and Documents:

- *ISO 19115 - Geographic information — Metadata*
- *ISO 19139 – Geographic Information – Metadata – XML Schema Implementation*
- *Requirements for Aviation Metadata and Guidance on the Aviation Metadata Profile – available as OGC Discussion Papers: http://portal.opengeospatial.org/files/?artifact_id=41667 and http://portal.opengeospatial.org/files/?artifact_id=41668*

ISO 19115 defines a schema for describing geographic information and services. It provides information about the identification, the extent, the quality, the spatial and temporal schema, spatial reference, and distribution of digital geographic data. It is applicable to:

- the cataloguing of datasets, clearinghouse activities, and the full description of datasets;
- geographic datasets, dataset series, and individual geographic features and feature properties.

It defines:

- mandatory and conditional metadata sections, metadata entities, and metadata elements;
- the minimum set of metadata required to serve the full range of metadata applications (data discovery, determining data fitness for use, data access, data transfer, and use of digital data);
- optional metadata elements – to allow for a more extensive standard description of geographic data, if required;
- a method for extending metadata to fit specialized needs.

ISO 19139 defines the Geographic MetaData XML (gmd) encoding, an XML Schema Implementation derived from ISO 19115. It provides an encoding schema for describing, validating, and exchanging metadata about geographic datasets, dataset series, individual geographic features, feature attributes, feature types, feature properties, etc. It is conformant with OGC GML 3.2.1.

The “Requirements for Aviation Metadata” and “Guidance on the Aviation Metadata Profile” (developed by the Aviation DWG within OGC) aim to list the user requirements for metadata in the aviation domain, using aviation specific sources (ICAO, INSPIRE & ADQ (Europe), the Airport GIS database (FAA)…) and to explain how to map these requirements in ISO 19115 / ISO 19139.

4.5.8 Filter Encoding

Relevant Specifications:

- *ISO 19143 Geographic Information – Filter Encoding / OGC Filter Encoding Implementation Specification 2.0*, available at http://portal.opengeospatial.org/files/?artifact_id=39968

The OGC Filter Encoding Implementation Specification describes an XML encoding of the OGC Common Catalog Query Language (CQL) as a system neutral representation of a query predicate. The filter encoding is a common component used by a number of OGC Web Services (e.g. WFS) requiring the ability to query objects from a web-accessible repository.

FE 2.0 will be used in the Aviation Thread to support AIXM and WXXM queries.

4.5.9 Event Pattern Markup Language

Relevant Specifications:

- *Event Pattern Markup Language (EML) Discussion Paper (http://portal.opengeospatial.org/files/?artifact_id=29566)*

The Event Pattern Markup Language (EML) allows one to describe event patterns for event (stream) processing and analysis. It can be used to build multi stage filters for incoming events but also to derive higher information through combining and correlating multiple events. It can be applied on single events but is focused on handling of continuous event streams.

4.5.10 SLD

Relevant Specification and Documents:

- *ISO 19117:2005 – Geographic Information- Portrayal*
- *OpenGIS Styled Layer Descriptor Profile of the Web Map Service Implementation Specification (OGC 05-078r4) and OWS-6 Styled Layer Descriptor (SLD) Changes ER,* available on http://www.opengeospatial.org/standards/sld
- *OGC 10-127r1 – OWS-7 Aviation Portrayal Engineering Report* http://portal.opengeospatial.org/files/?artifact_id=40134
- OGC OWS-9 Engineering Report - Guidelines for International Civil Aviation Organization (ICAO) portrayal using SLD/SE https://portal.opengeospatial.org/files/?artifact_id=46228
- *OpenGIS Symbology Encoding Implementation Specification (OGC 05-077r4)* http://portal.opengeospatial.org/files/?artifact_id=16700
- *OGC 09-016 – OWS-6 Symbology Encoding (SE) Changes ER* http://portal.opengeospatial.org/files/?artifact_id=33515
- *OGC 05-012r1 – Symbology Management* http://portal.opengeospatial.org/files/?artifact_id=13285

The OWS-9 Aviation Thread will build on the portrayal work of previous OGC IP Aviation work (OWS-9, OWS-7 and the FAA SAA Dissemination Pilot) focusing on the separation of Portrayal Rules, Symbol Sets, and Portrayal specifications from the AIXM and WXXM feature data, and on demonstrating the ability of applying different styles/symbols to the same feature data depending on the styling rules used (which can be influenced by the type of Aviation Client- handheld vs. dispatch, or decision-making purpose). The separation can be achieved by applying the OGC Styled Layer Descriptor (SLD) specifications (in conjunction with the Feature Portrayal Service (FPS) and the Catalog Service for the Web (CSW)) to demonstrate the potential of a scalable, flexible and interoperable architecture for producing customizable maps from source AIXM and WXXM data by supporting different symbology (styles and symbols) and portrayal rules. Styles, encoded using OGC Symbology Encoding (SE), describe styling attributes that can be applied to particular features in the portrayal process. Symbols are generic graphical entities referenced in styles and used in the FPS in the styling process.

4.6 Aviation Computational Viewpoint

The computational viewpoint is concerned with the functional decomposition of the Aviation architecture into a set of services that interact at interfaces. It reflects the components, interfaces, interactions and constraints of the Service Architecture without regard to their distribution. For the Aviation thread of OWS-9, those services are

- Web Feature Service (WFS) for access to aeronautical and weather information.
- Feature Portrayal Service (FPS) for portraying AIXM and WXXM feature data by applying SLD feature style descriptions.
- Event Service (based on OASIS Web Services Notification) for the automatic delivery of information updates to interested clients
- Catalog Service for the Web (CSW) ebRIM for managing service metadata as well as publication, discovery and access to symbols, styles and code lists for AIXM and WXXM.
- Web Processing Service (WPS) for executing spatial computations
- Data Management Service (DMS) for managing data transmission between clients located on an aircraft and information management services located on the ground.
- Aviation Clients.

4.6.1 Web Feature Service

Relevant Specifications:

- *ISO 19142: Geographic information - Web Feature Service, 2010-04-26,* OGC document #09-025r1, http://www.opengeospatial.org/standards/wfs

The WFS Implementation Specification allows a client to retrieve and update geospatial data encoded in Geography Markup Language (GML) from multiple Web Feature Services. It defines interfaces for data access and manipulation operations on geographic features, usually using http as the distributed computing platform. A Transactional WFS allows creation, deletion and updating of features in addition to querying and retrieval of features.

WFS 2.0 will be used in the Aviation thread to serve and query AIXM 5.1 aeronautical features including airports, airspace, navigational aids and fixes, obstacles, and/or procedures (approaches). The WFS shall support transactions (for posting events and updating features accordingly). WFS 2.0 will also be used to serve and query WXXM 1.1.3 data.

4.6.2 Feature Portrayal Service

Relevant Specifications & Documents:

- *Feature Portrayal Service and Styled Layer Descriptor*: *OpenGIS Styled Layer Descriptor Profile of the Web Map Service Implementation Specification (OGC 05-078r4) and OWS-6 Styled Layer Descriptor (SLD) Changes ER,* available on http://www.opengeospatial.org/standards/sld
- *OGC 10-127r1 – OWS-7 Aviation Portrayal Engineering Report* http://portal.opengeospatial.org/files/?artifact_id=40134
- OGC OWS-9 Engineering Report - Guidelines for International Civil Aviation Organization (ICAO) portrayal using SLD/SE https://portal.opengeospatial.org/files/?artifact_id=46228
- *OGC 05-012r1 – Symbology Management* http://portal.opengeospatial.org/files/?artifact_id=13285

Portrayal Services provide specialized capabilities supporting visualization of geospatial information. Portrayal Services are components that, given one or more inputs, produce rendered outputs (e.g., cartographically portrayed maps, perspective views of terrain, annotated images, views of dynamically changing features in space and time, etc.) Portrayal Services can be tightly or loosely coupled with other services such as Data and Processing Services and transform, combine, or create portrayed outputs. Portrayal Services may use styling rules specified during configuration or dynamically at runtime by Application Services.

The FPS is an extension of the basic Web Map Server. The FPS WMS inherits all of the attributes from the Web Map Server and adds support for the use of Styled Layer Descriptor documents to specify styling. Instead of generating maps of particular named layers in one or more predefined styles, an SLD Map Server extracts features from a data provider and renders them using a stylistic description encoded in XML. The FPS may return a graphic image or a "styled" data encoding format such as KML. The styles and symbols can be stored in a Catalog Service for the Web (CSW) as shown in Figure 12

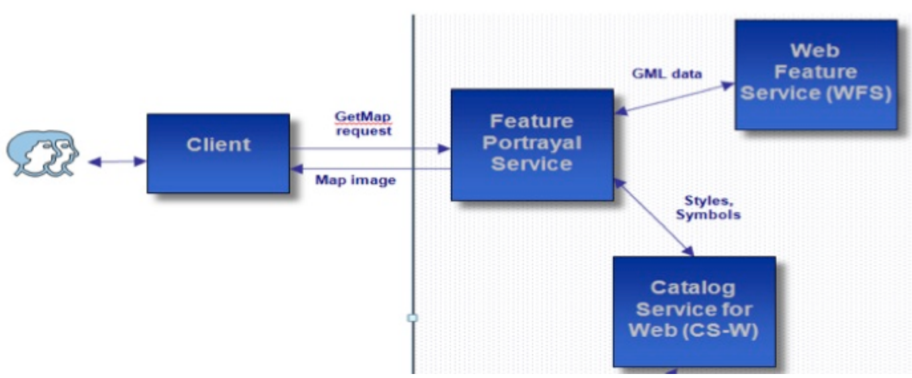

Figure 12 – Feature Portrayal Service

The Aviation Thread of OWS-9 will continue the work from previous OGC IPs (OWS-9, OWS-7 and the FAA SAA Dissemination Pilot) to support the separation of Portrayal Rules, Symbol Sets, and Portrayal specifications from the AIXM and WXXM feature data, and to demonstrate the ability of applying different styles/symbols to the same feature data depending on the styling rules used (which can be influenced by the type of Aviation Client- handheld vs. dispatch, or decision-making purpose). The separation can be achieved by using the FPS as a portrayal engine for AIXM and WXXM data to demonstrate the potential of a scalable, flexible and interoperable architecture for producing customizable maps from source AIXM and WXXM data by supporting different symbology (styles and symbols) and portrayal rules.

4.6.3 Event Service

Relevant Specification and Documents:

- *OGC Event Service - Review and Current State (OGC 11-088r1)* https://portal.opengeospatial.org/files/?artifact_id=45850
- *OGC 11-093r2 OWS-8 Aviation Architecture Engineering Report* https://portal.opengeospatial.org/files/?artifact_id=46242

The Aviation Thread of OWS-9 will advance the Event Service component developed in previous OGC IPs (OWS-6 to OWS-9 and the FAA SAA Dissemination Pilot) to enable information producers to publish notifications/events (such as Digital NOTAMs) and to notify information consumers (Clients) of events that match their subscription criteria (Figure 13). The Event Service is implemented based upon the OASIS Web Services Notification standard which leverages W3C standards (such as WS-Addressing and usually also SOAP).

Figure 13 – Event Service Overview

4.6.4 OASIS Web Services Notification

Relevant Specifications:

- *OASIS WSN Base Notification 1.3 , OASIS WS-Topics 1.3 and OASIS WSN Brokered Notification 1.3,* available on http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=wsn

The purpose of the OASIS Web Services Notification is to define a set of specifications that standardize the way Web services interact using "Notifications" or "Events". They form the foundation for Event Driven Architectures built using Web services. These specifications provide a standardized way for a Web service, or other entity, to disseminate information to a set of other Web services, without having to have prior knowledge of these other Web Services. They can be thought of as defining "Publish/Subscribe for Web services".

The WS-Notification family of specifications defines a standard Web services approach to notification.

4.6.5 OASIS WS-Reliable Messaging

Relevant Specifications and Documents:

- *OASIS Web Services Reliable Messaging (WS-ReliableMessaging) Version 1.2*, available at http://docs.oasis-open.org/ws-rx/wsrm/200702

It is often a requirement for two Web services that wish to communicate to do so reliably in the presence of software component, system, or network failures. The primary goal of WS-ReliableMessaging is to create a modular mechanism for reliable transfer of messages. It defines a messaging protocol to identify, track, and manage the reliable transfer of messages between a source and a destination.

4.6.6 Web Processing Service (WPS)

Relevant Specifications and Documents:

- *Web Processing Service Version 1.0, OGC Document 05-007r7 (http://www.opengeospatial.org/standards/wps)*
- *Corrigendum for WPS 1.0, OGC Document 08-091r6 (http://www.opengeospatial.org/standards/wps)*
- *OWS-7 Web Processing Service Profiling Engineering Report, OGC Document 10-059r2 (http://www.opengeospatial.org/standards/wps)*

The WPS defines a standardized interface that facilitates the publishing of geospatial processes, and the discovery of and binding to those processes by clients. Processes include any algorithm, calculation or model that operates on spatially referenced data. Publishing means making available machine-readable binding information as well as human-readable metadata that allows service discovery and use.

The WPS provides mechanisms to identify the spatially referenced data required by the calculation, initiate the calculation, and manage the output from the calculation so that the client can access it.

4.6.7 Web Notification Service

Relevant Specifications and Documents:

- *Web Notification Service Best Practices Paper (http://portal.opengeospatial.org/files/?artifact_id=18776)*

The Web Notification Service (WNS) supports asynchronous service handling. WNS instances forward incoming messages on various transport protocols (e.g. email, HTTP, Instant Messaging, phone etc) to clients. The service interface allows clients to register a target address and protocol, which will be used to deliver messages from calling services that need to inform clients about specific events. The service thereby also enables routing a message to multiple recipients.

4.6.8 CSW ebRIM

Relevant Specifications and Documents:

- *OGC 07-006r1 OGC Catalog Service (CSW) Implementation Specification 2.0.2 and CSW-ebRIM Registry Service specifications,* available on http://www.opengeospatial.org/standards/specifications/catalog

The OGC Catalog Service supports the ability to publish and search collections of descriptive information (metadata) for data, services, and related information objects. Metadata in catalogs represent resource characteristics that can be queried and presented for evaluation and further processing by both humans and software. The Catalog Service supports the discovery and binding to these registered information resources within an information community.

Note that the CSW ebRIM servers are usually cross-thread components, supporting the catalog requirements of multiple threads.

4.6.9 OWS-9 Aviation Client requirements

The Aviation Clients in the Aviation Thread of OWS-9 are critical to demonstrating interoperability of the web services used in the thread as well as highlighting the potential value of interoperable access, filtering, integration and portrayal of AIXM/WXXM data and events. Furthermore, the clients are key to demonstrating the new data transmission management functionality.

The Aviation Clients can be developed as either thin or thick clients, and can act as proxies for EFB/handheld applications, avionic system applications, flight dispatch/airline operations applications, or any other applications that can benefit from the combination of functionality developed during the thread in support of the Enterprise Viewpoint scenarios.

4.7 Aviation Engineering Viewpoint

The Enterprise, Information, and Computation viewpoints describe a system in terms of its purposes, its content, and its functions. The Engineering viewpoint identifies component types in order to support distributed interaction between the components of the system. Those components interact based upon the services identified and described in the Computational viewpoint.

Figure 14 provides an overview of the components of the Aviation thread, organized based on the ISO 3-tier model with the top tier dealing with clients, the middle tier embodying the business processes required to respond to requests issued by clients, and a lower tier focusing on provision of data. Note that in order to minimize the complexity of the engineering viewpoint, the figure does not show all possible interactions amongst the identified components.

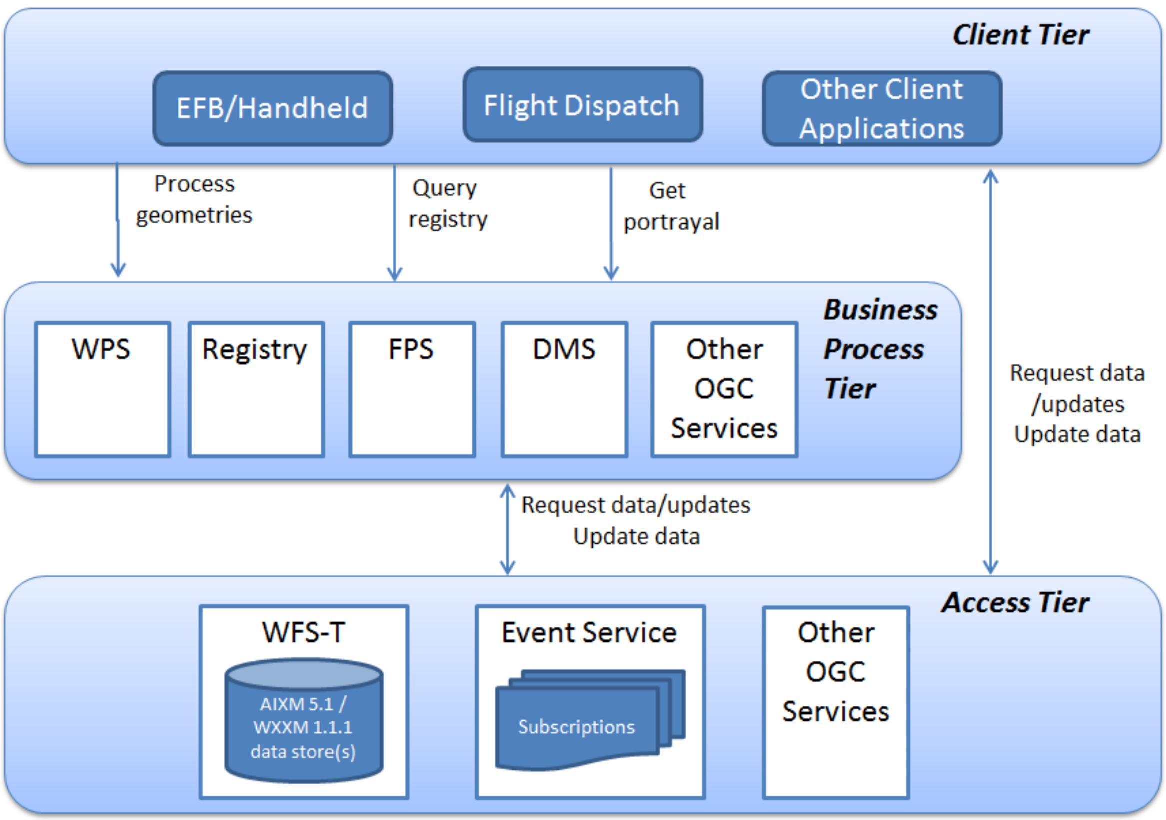

Figure 14 – Aviation Thread Engineering Viewpoint

The following figure illustrates how the Data Management Service (DMS) is used to establish an efficient communication link between the information management services located on the ground and a client application located in an aircraft.

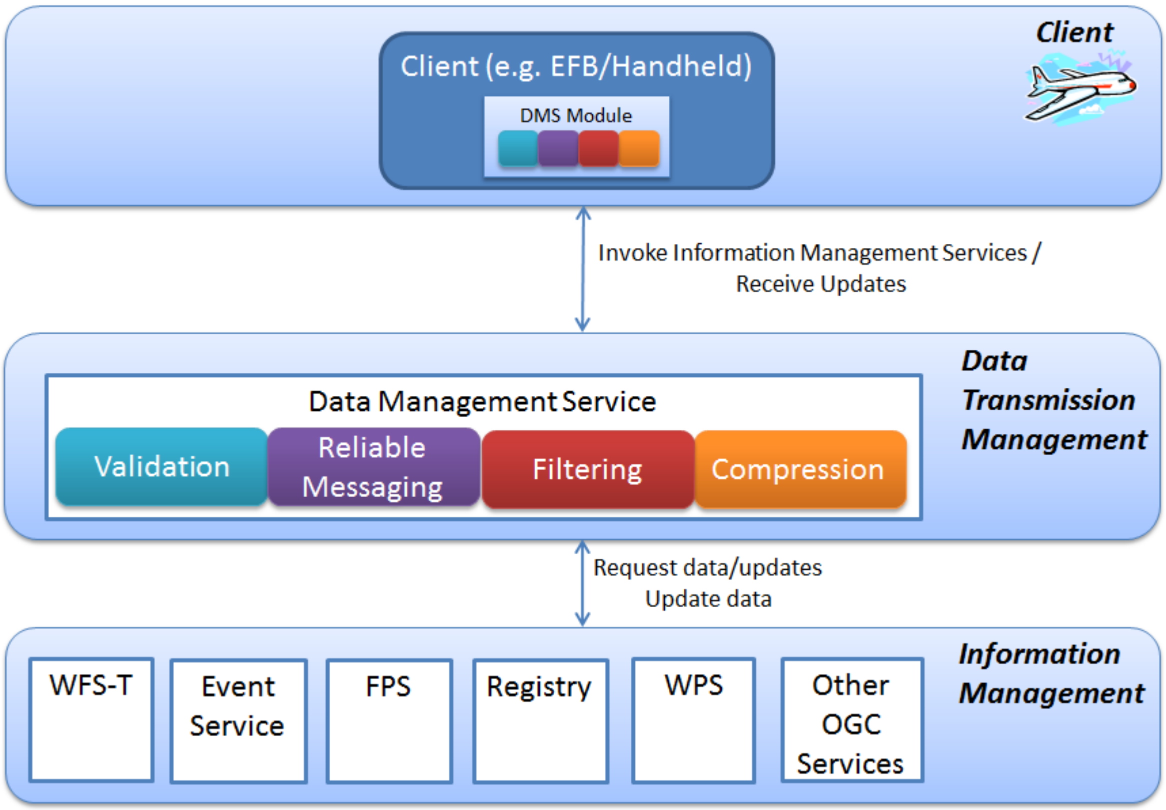

Figure 15 – Data Transmission Management

The communication link between client and DMS is provided via wireless data link (not shown in the figure). This link can be Wi-Fi while the aircraft is still at the airport, a satellite or other suitable[3] link while the aircraft is in flight. The DMS is responsible for an efficient use of the wireless data link. The communication link between DMS and the information management services is provided via terrestrial, high-speed/broadband Internet.

Note: a solution for realizing data transmission management should be designed in such a way that it has none to minimal impact on the way that a client would communicate with the information management services if data transmission management was not required, for example if both the client and services are connected via terrestrial, high-speed/broadband Internet. This is illustrated via the “DMS Module”, which may be realized as a layer that is added to the client application layer (which encapsulates the client business logic for using the information management services). This additional layer then automatically performs data transmission management functionality with none to minimal integration with the application layer.

[3] Prime example of this in the domestic US is a 3Gb/s CDMA Rev A terrestrial solution.

5 OWS-9 Thread: Cross-Community Interoperability (CCI)

5.1 CCI Thread Scope

The Cross-Community Interoperability (CCI) thread seeks to build on the work accomplished in OWS–8 by increasing interoperability within communities sharing geospatial data. This thread will advance semantic mediation approaches for data discovery, access and use of heterogeneous data models and heterogeneous metadata models. The work to be performed in this thread includes the following:

- **Semantic mediation**:
  - Advancement of semantic mediation approaches to query and discover data, which have been described using different metadata models, including non-traditional OGC metadata models.
  - Advancement of semantic mediation approaches to query and discover data, which have been described using different data models, including non-traditional OGC data models.
- **Query Results Delivery**
  - Advancement of using Security to filter and route query results.
  - Advancement of using OWS-Context for results delivery.
- **Data Provenance and Quality:**
  - Advancement of using a web based data processing facility for managing and visualizing provenance and quality of data.
  - Advancement of managing data provenance in OGC Web Services.
- **SPEGG**: Advancement of semantic mediation approaches to provide a Single Point of Entry Global Gazetteer.

5.2 CCI Thread Requirements

References

- CSW – OpenGIS Catalogue Service Implementation Specification (2.0.2) 07-006r1 http://www.opengeospatial.org/standards/cat
- FGDC-STD-001-1998 - The Content Standard for Digital Geospatial Metadata (CSDGM) version 2 http://www.fgdc.gov/metadata/geospatial-metadata-standards#csdgm
- ISO 19115:2003 Geographic information Metadata http://www.iso.org/iso/catalogue_detail.htm?csnumber=26020
- ISO 19115-2:2009 - Geographic information -- Metadata -- Part 2: Extensions for imagery and gridded data
- ISO 19157 Geographic information — Data quality
- http://www.iso.org/iso/catalogue_detail.htm?csnumber=39229

- NSG Metadata Foundation (NMF) 2.1 – NMF Metadata Implementation Specification (NMIS)
- NMF – Part 2 Quality Metadata
- OpenStreetMap - Wikiguide http://wiki.openstreetmap.org/wiki/Beginners_Guide_1.1
- NITF version 2 - National Imagery Transmission Format http://www.globalsecurity.org/intell/systems/nitfs.htm
- OGC GeoSPARQL – A Geographic Query Language for RDF Data (11-52r4)
- OWS-8 CCI Semantic Mediation ER (11-063r6) https://portal.opengeospatial.org/files/?artifact_id=46342
- SPARQL Query Language for RDF. W3C Recommendation 15 January 2008. http://www.w3.org/TR/rdf-sparql-query/
- TDS – NSG Topographic Data Store - Content Spec V3.0: https://nsgreg.nga.mil/as/view?i=82045
- The Specification Model - A Standard for Modular specifications (08-131r3) https://portal.opengeospatial.org/files/?artifact_id=34762
- TNM - USGS The USGS National Map. http://nationalmap.gov/

5.2.1 Advance Data and Service Discovery

5.2.1.1 Overview

The purpose of this set of requirements is to investigate, evaluate, and demonstrate through OGC new and/or existing services the benefit of semantic mediation approaches to support discovery of pertinent services or data collections providing semantically equivalent or relevant data. The solution should provide enhanced Semantic Mediation capabilities for data discovery including open source search, OGC and non-OGC based services, multiple service interfaces, crowd-sourced volunteered geographic information (VGI). Some of these data may not have metadata at all. Some data sources may contain very little traditional metadata content and can only be identified as relevant to other data sources through a geospatial element (e.g. coordinates), which identifies its common location or a textual description (e.g. place name). The capability to be advanced includes a prototyped architecture and a set of deployable services. The requirements are as follows:

5.2.1.2 Develop architecture based on CCI OWS–8 Thread

Identify and develop architecture to support the requirements of this thread. This architecture shall leverage the results and lessons learned as a result of OWS–8 CCI Semantic Mediation work.

5.2.1.3 Allow metadata semantic equivalency

The solution should allow the creation of semantic equivalency between differing metadata models for the purpose of content discovery.

5.2.1.4 Map NSG, NMF, FGDC, ISO, Open Street Map metadata standards

At a minimum the solution shall provide a set of semantic mappings between the following metadata models:

- NSG Metadata Foundation (NMF) 2.1 – NMF Metadata Implementation Specification (NMIS)
- NMF – Part 2 Quality Metadata
- Federal Geographic Data Committee (FGDC) Metadata
- ISO 19115
- Open source minimal metadata (e,g, Open Street Map)

5.2.1.5 Include TDS, TNM, Open Street Map and VGI data

Data content to be evaluated for semantic mediation and post-processing are as follows:

- Topographic Data Store (TDS) data model from NGA via OGC Services
- The National Map Data (TNM) Model from USGS via OGC Services
- Open Street Map
- Crowd-sourced VGI (textual and geospatial), as for example, twitter, youTube and Flickr.

5.2.1.6 Allow general search capabilities

Develop a client and web services to allow consumers to submit a general search request (e.g., using the OpenSearch specification). Service Consumers shall be able to ascertain what information may be available based on a given set of search criteria. Consumers shall be able refine searches based on specific attributes of content collections and/or content resources (CSW).

5.2.1.7 Include Open Search for crowd-sourced data

Client and catalog should support OpenSearch capabilities to identify crowd-sourced information based on keywords or other mechanisms.

5.2.1.8 Provide statistical method for data relevance

Provide a method for determining the relevance of VGI data based on the frequency (count) of similar data entries being uploaded to open source or social networking sites. For example, a client can provide this capability by determining relevance based on number of results for a specific place of interest during a specific period of time.

5.2.1.9 Allow ability to add metadata

Provide the ability for a user to apply a minimum set of metadata that can then be used to reference/link that data to a geographic area, event, timeline and other data holdings.

5.2.1.10 Investigate standard registration of SPARQL servers

Investigate and implement the best standard mechanism to allow catalogs to express SPARQL server capabilities.

5.2.1.11 Propose standard development for SPARQL servers

Investigate an implement an approach to make SPARQL servers compatible with OGC web services. This can be achieved for example by publishing and making available a SPARQL server via a WPS.

5.2.1.12 Demonstrate semantic mediation of aviation data

The semantic mediation approach shall demonstrate how to query AIXM data based on terminology familiar to pilots. This work is similar to the work advanced in OWS-8, that allowed emergency responders to search data based on their own semantics. The web client/registry provided this functionality by invoking semantic similarities form advertised feature types and user terminologies form the knowledge base.

5.2.2 Advance Security of Query Result Delivery

5.2.2.1 Secure query results

Discovery and retrieval of data content and/or service endpoints may be influenced by the consumer's authorization to that information. The content of the query result set shall be influenced by security authentication and authorization (see SSI thread topic on security, Section 6.1).

5.2.2.2 Route and conditionally deliver results, content and metadata

Query Results Delivery includes the ability to route and conditionally deliver content, search results, and metadata to receiving consumers (see SSI thread topic on security, Section 6.1)

5.2.3 Advance OWS Context for Results Delivery

References

- ATOM - Atom Syndication Format - http://en.wikipedia.org/wiki/Atom_(standard)
- JSON JavaScript Object Notation http://www.json.org/
- HTML5 - A vocabulary and associated APIs for HTML and XHTML http://dev.w3.org/html5/spec/Overview.html
- OWS Context 1.0 - Standard Working Group page at the OGC Portal http://www.opengeospatial.org/projects/groups/owscontextswg (public), https://portal.opengeospatial.org/?m=projects&a=view&project_id=364&tab=0 (OGC member only – available upon request)

5.2.3.1 Investigate the use of OWS Context as results delivery mechanism

Solution should provide an investigation of the ability to use OWS Context as the delivery mechanism for the results of the query to the consumer. The OWS Context standard will be more mature towards the end of the OWS–9 period.

5.2.3.2 Test and evaluate different encodings for OWS Context

Test and evaluate the relative benefits of different encoding methods prior to finalization of the draft standard. OWS Context has been proposed with an Atom encoding, a JSON encoding and an HTML5 encoding. This requirement seeks to understand the level of mass-market acceptance of these different encoding options and their ability to support mash-ups. Each encoding should be evaluated, including examples and recommendations to move forward. Recommendations should enable OWS Context capability for OGC services while remaining cognizant of implementations using mass-market technologies.

The contractor shall provide client(s) capable of visualizing the content of the OWS Context document.

5.2.3.3 Allow to read and display OWS Context document

Implementation should allow reading and displaying the content of OWS Context document, supporting the work related to the requirement to Test and evaluate different encodings for OWS Context.

5.2.4 Advance Evaluation of Query Results

Provenance of data is important because data is created with a particular purpose in mind. It targets some known user requirements. Everybody seems to agree that quality information has to be provided in a way that a user is able to know if the data fits his purpose. This immediately generates scenarios where the use is looking for a dataset and will try to use it for a completely different purpose than its intended use. Quality indicators can help the user assess if the information presented is useful or not, when they haven't created the data.

5.2.4.1 Provide data semantic equivalency via a semantic mediation service

Implement a semantic mediation service capable of providing the consumer with a semantic equivalency analysis result. The result shall help on estimating uncertainty of potential data matches performed on data content (e.g. position, feature name, feature attributes).

5.2.4.2 Enable visual representation to support uncertainty and quality in mediation process

Enable capability of visually representing a quality result-set based on the results of the uncertainty estimation, the content of the metadata and the nature of the associated data. Information such as this will be required by the user in the development of rules for integration into the Rules Service and Conflation Service. An integrated client should provide data quality indicators and flags for:

- Product/dataset/sensor level quality as text data.
- Pixel/feature quality in the map view as an extra style and/or synchronized window.
- Provenance represented as a tree or network (for workflows) with the possibility to show/switch the source data from the provenance tree.

5.2.5 Advance web based data processing including provenance and quality

As indicated in previous sections data and service discovery may include resources which hold equivalent feature content but that content may be based on differing data models. To make efficient use of such data it will be necessary to combine the data content where appropriate making use of single best position or single best resolution/geometry with a combined set of attribution. In order to accomplish this task the development of a Web Processing Service for Conflation is required. A client interacts with the conflation service as an integrated approach for a conflation solution. The requirements for this conflation service and the client are as follows:

5.2.5.1 Develop conflation rules for vector and raster data.

Support the creation of conflation rules to align data, identify new information (geometry or attribute), and conflate into common dataset.

5.2.5.2 Allow interactive data registration for vector and raster data

Client shall allow the registration of vector and raster data.

5.2.5.3 Allow visual interaction for conflation and analysis

The conflation service shall make use of the semantic mediation processes and client visualization to demonstrate alignment analysis of data from two or more datasets. The integrated client shall support the analysis/development of data quality and confidence indicators.

5.2.6 Advance managing of data provenance in OGC Web Services

References

- ISO 19115:2003 Geographic information Metadata http://www.iso.org/iso/catalogue_detail.htm?csnumber=26020
- NMF – Part 2 Quality Metadata

Data Provenance should be properly capture and propagated through OGC services. This end result shall include a metadata framework to provide the data source, quality, confidence, and change history base don ISO 19115 / NMF Part 2 Data Quality Metadata,

5.2.6.1 Investigate data quality exposure in OGC services and encodings

Investigate how data quality and provenance information, using ISO 19115 can be exposed in OGC services and encodings. This will allow maintaining and consistently propagating metadata as express further requirements.

5.2.6.2 Maintain the data provenance of processed data in metadata of new combined dataset

Maintain the data provenance of the individual parts of data merged, when performing Web Based Data Processing, by generating output metadata content which shall be added as either feature or attribute level metadata for the new combined feature or dataset.

5.2.6.3 Maintain link of process step and source

While performing web-based data processing, it shall be necessary to maintain a link between the process step, which created the derived data, and the source from which the data originated. This end result shall include a metadata framework to provide the data source, quality, confidence, and change history (see ISO 19115 / NMF Part 2 Data Quality Metadata).

5.2.7 Advance Single Point of Entry Global Gazetteer

References

- ADL - Alexandria Digital Library Feature Type Thesaurus http://www.alexandria.ucsb.edu/gazetteer/FeatureTypes/ver070302/index.htm
- GeoNames -http://www.geonames.org/

- GNIS – Geographic Names Information System, managed by USGS, first developed in 1964 and currently contains information about domestic and Antarctic names. http://nhd.usgs.gov/gnis.html
- GNS – GeoNET Names Server which serves the Geographic Names Data Base (GNDB) managed by National Geospatial- Intelligence Agency (NGA), has been in service since 1994, and serves names for areas outside the United States and its dependent areas, as well as names for undersea features. http://earth-info.nga.mil/gns/html/
- WFS-G – Gazetteer Service - Application Profile of the Web Feature Service Candidate Implementation Standard (1.0) 11-122r1 RFC https://portal.opengeospatial.org/files/?artifact_id=46964
- TDS – NSG Topographic Data Store - Content Spec V3.0: https://nsgreg.nga.mil/as/view?i=82045
- TNM - USGS The USGS National Map. http://nationalmap.gov/

The US Government lacks a Single Point of Entry Global Gazetteer (SPEGG), where a user can submit a single query and access global geographic names data across multiple Federal names databases. This is a hindrance to military and civilian users who require access to names data both within and outside the United States. Currently users must make two queries with differing input parameters against two separate databases to obtain authoritative cross border geographic names data. Resolution of this issue will build on the semantic interoperability work of OWS–8, which addressed the differences between NGA's Topographic Data Store (TDS) to USGS's National Map (TNM) feature type data dictionaries.

This thread will advance the technologies to enable Single Point of Entry Global Gazetteer, subject to the following requirements.

5.2.7.1 Implement a WFS-G cascading service with semantic mediation capabilities

5.2.7.2 Map GNIS and GNS feature types

Provide a new mapping for the gazetteer databases at USGS and NGA following a different feature coding standards than the one previously done in OWS-9 with TDS and TNM. Mapping should be available from GNIS to GNS and from GNS to GNIS.

5.2.7.3 Map a third mediating feature type

Map GNIS to GNS to a third mediating source (e.g. ADL or GeoNames). The mediating source will provide similar functionality as the Rosetta Mediation Model from OWS-9.

5.2.7.4 Make available at least three geographic names databases via web services

Make available via web services at GNIS, GNS and others.

5.2.7.5 Implement a client to access multiple geographic names

Implement a client to access at least three geographic names databases through web services.

5.2.7.6 Implement Semantic Mediator

The semantic query should support the native mappings from GNIS to GNS, as well as mappings to a third data dictionary

5.2.7.7 Specify metadata about the type of mapping in query results

The query results should specify the type of mapping for each record in the query result as was done in OWS–8, i.e., no mapping, one-to-one mapping, one-to-many mapping, or many-to-one mapping.

5.2.7.8 Investigate new category mapping one-to-one with one-to-many

Investigate a potential new category, where a one-to-one and one-to-many relationship may exist simultaneously. This is the case with the PPL feature class in the USGS and NGA databases. There is a one-to-one match with PPL feature classes between USGS and NGA, but also a one-to-many relationship where one USGS feature class might map to many NGA PPL feature classes (which include an exact PPL match, but other classes as well, such as abandoned populated place -PPLQ, or destroyed populated place - PPLW, which are not found in the USGS feature classes). To further complicate the situation, the PPLQ and PPLW could map to the USGS historic feature type, which does not distinguish between the feature types of the original features.

5.2.7.9 Revisit WFS standard for response completeness

Revisit the WFS standard to insure that the user is aware of the completeness of the WFS response and has a mechanism to obtain all the data in an efficient manner. The mechanism will allow the user to both identify the number of records in the query recordset, as well as obtain a complete query recordset, either with one query or over multiple queries. The WFS/WFS-G standards currently allow the user to specify the number of records returned from a query, but it provides no indication of the completeness of the returned records. For example, the user may request that 100 records be returned, and receive 100 records. The user has no idea if there are only 100 records in the query response or if there are 3000 records in the query response and only the first 100 are returned.

5.2.7.10 Implement service interface to query geographic names similar to current web interfaces

Demonstrate the clients and services required to support querying geographic names data from databases using the current web interfaces. For basic queries, this includes an ability to query on the name, feature type (requiring semantic mediation), and a spatial constraint.

5.2.7.11 Implement advance filter of query names

Searches on the geographic name should be filtered by name using the following constraints:

- Starts With
- Ends with
- Contains
- Fuzzy Match

5.2.7.12 Handle diacritics and special characters in searches

Searches on the geographic name should enable flexible handling of names with diacritics and special characters represented by UNICODE and search for names with diacritics and without diacritics The resulting diacritics should be displayed properly in the client.

5.2.7.13 Implement advance spatial constraints

The spatial constraints are of two types:

- An administrative region, i.e., specifying a country to limit the results.
- Spatial filter such as a bounding box or a radial search.

Searches by administrative regions shall be limited as follows: countries, 1st order administrative regions, and 2nd order administrative regions. NGA searches support a country filter and USGS searches support a state and optional county filter.

5.2.7.14 Implement advance gazetteer query services

Support advanced services that go beyond the basic query of the database: These include:

- Find the closest x features given a latitude/longitude coordinate and optional feature type
- List the administrative hierarchy for a feature (for administrative features) including features at higher and lower levels
- List the elevation of a feature (by intersecting the coordinates of the feature with a DEM)

5.3 CCI Thread Deliverables

The Deliverables are summarized in the Table with descriptions of the Deliverables in paragraphs following the table.

Table 2 – CCI Thread Deliverables Summary

1. OWS-9 CCI Semantic Mediation Engineering Report
2. Metadata encodings for semantic mediation
3. Mediation Information Models, Encodings and Mappings for data
4. Change Requests – Semantic Mediation
5. Semantic Mediator Component
6. Semantic Mediation Service – Knowledge Base SPARQL
7. Semantic Mediation Service – Catalog for VGI
8. Semantic Mediation Service – WFS for Semantic Mediation
9. OWS-9 CCI OWS Context evaluation Engineering Report
10. OWS Context document for CCI
11. OWS Context encoding examples for CCI
12. OWS-9 CCI Conflation with Provenance Engineering Report
13. Conflation rules encoding
14. Conflation Web Processing Service
15. CCI Integrated Client
16. OWS-9 CCI Single Point of Entry Global Gazetteer Engineering Report
17. Web Feature Service 2.0 for USGS TNM
18. Web Feature Service 2.0 for NGA TDS
19. WFS-G for GNIS
20. WFS-G for GNS
21. WFS-G semantic mediator
22. Catalog for Provenance
23. Client for Single Point of Entry Global Gazetteer

5.3.1 OWS-9 CCI Semantic Mediation Engineering Report

This Engineering Report will include description of the work performed, gaps and proposed future work related to the work performed on this thread. The report shall be based on the OWS–8 CCI Semantic Mediation ER. This ER shall include a description of the architecture, service implementations, workflows and any recommendations. This ER shall contain the following sections among others: Architecture and Design, Semantic Metadata Mediation, Semantic Data Mediation, SPARQL service.

This deliverable is related to the following requirements:

- Advance Data and Service Discovery
- Advance Security of Query Result Delivery
- Advance OWS Context for Results Delivery
- Advance Evaluation of Query Results

5.3.2 Metadata encodings for semantic mediation

Machine-readable format (e.g. in RDF) of encodings used for the metadata semantic mediation. Encodings include: the mediation information model, any representation of metadata models required for mediation, the semantic mappings, and example encodings for instances of each metadata model.

This deliverable is related to the following requirement:

- Map NSG, NMF, FGDC, ISO and Open Street Map,metadata standards

5.3.3 Mediation Information Models, Encodings and Mappings for data

Provide mediation information models, encodings and mappings for data,

This deliverable is related to the following requirements:

- Include TDS, TNM, Open Street Map and VGI data.

5.3.4 Change Requests – Semantic Mediation

Change Requests to OGC specifications as required. Modifications or enhancements to the OGC suite of standards as needed to support the concept and implementation of Semantic Mediation capabilities.

Semantic Mediation Service – Knowledge Base SPARQL

5.3.5 Semantic Mediator Component

Enhanced Semantic Mediation capabilities to support service and data discovery through service and data content metadata to include open source search, OGC and non-OGC based services, multiple service interfaces, crowd-sourced volunteered geographic information (VGI).

This deliverable is related to the following requirements:

- Include TDS, TNM, Open Street Map and VGI data.
  Advance Single Point of Entry Global Gazetteer / Implement Semantic Mediator

5.3.6 Semantic Mediation Service - Knowledge Base SPARQL

Component of the suite of prototype Semantic Mediation services to support enhanced capability requirements. The knowledge base SPARQL Server shall support managing and retrieving of mappings for data (and data models) and metadata.

This deliverable is related to the following requirements:

- Investigate standard registration of SPARQL servers
- Propose standard development for SPARQL servers
- Demonstrate semantic mediation of aviation data
- Allow metadata semantic equivalency
- Map NSG, NMF, FGDC, ISO,and Open Street Map metadata standards
- Include TDS, TNM, Open Street Map and VGI data
- Provide data semantic equivalency via a semantic mediation service
- Map GNIS and GNS feature types
- Map a third mediating feature type
- Demonstrate semantic mediation of aviation data

5.3.7 Semantic Mediation Service - Catalog for VGI

Component of the suite of prototype Semantic Mediation services to support enhanced capability requirements. The catalogue exposes social web sources through OpenSearch Geo.

This deliverable is related to the following requirements:

- Map NSG, NMF, FGDC, ISO and Open Street Map metadata standards
- Include TDS, TNM, Open Street Map and VGI data
- Allow general search capabilities
- Include Open Search for crowd-sourced data
- Investigate the use of OWS Context as results delivery mechanism
- Test and evaluate different encodings for OWS Context

5.3.8 Semantic Mediation Service – WFS/WMS for Semantic Mediation

Component of the suite of prototype Semantic Mediation services to support enhanced capability requirements. The WFS /WMS semantic mediator mediates across WFS data models.

This deliverable is related to the following requirements:

- Map NSG, NMF, FGDC, ISO and Open Street Map metadata standards
- Include TDS, TNM, Open Street Map and VGI data
- Demonstrate semantic mediation with aviation data

5.3.9 OWS-9 CCI OWS Context evaluation Engineering Report

Engineering Report documenting the results of an analysis of the benefits and drawbacks associated with the different encoding options for OWS Context, including Atom, JSON and HTML5.

This deliverable is related to the following requirements:

- Advance OWS Context for Results Delivery

5.3.10 OWS Context document for CCI

OWS Context document for delivery of refined query results based on authorization rules.

This deliverable is related to the following requirements:

- Advance OWS Context for Results Delivery

5.3.11 OWS Context encoding examples for CCI

Encoding examples for OWS Context document in Atom, JSON, and HTML5.

This deliverable is related to the following requirements:

- Advance OWS Context for Results Delivery

5.3.12 OWS-9 CCI Conflation with Provenance Engineering Report

Engineering Report documenting the WPS Conflation Service and how Data Provenance is captured during the conflation processing. Description of the conflation rules encoding to be included. The report shall contain an encoding for provenance, adapted to distributed environments, that is able to link to data or services instances and their metadata record. It also includes how to retrieve provenance information from catalogues.

This deliverable is related to the following requirements:

- Advance web based data processing including provenance and quality
- Advance managing of data provenance in OGC Web Services

5.3.13 Conflation rules encoding

Encoding schemas and examples for conflation rules applicable to vector and raster data.

This deliverable is related to the following requirement:

- Develop conflation rules for vector and raster data.

5.3.14 Conflation Web Processing Service

Conflation service with WPS interface to support semi-automated client supported, interactive data registration and conflation rules development for vector and raster data. Conflation service shall make use of the semantic mediation processes and client visualization to demonstrate alignment analysis of data from two or more datasets.

This deliverable is related to the following requirements:

- Advance Evaluation of Query Results
- Advance web based data processing including provenance and quality
- Advance managing of data provenance in OGC Web Services

5.3.15 CCI Integrated Client

Integrated Client to the various CCI services. Client will support: reading and displaying the content of OWS Context document; visualization or the semantic mediation process; creation of conflation rules with interface to Semantic Mediation service and Conflation Service; and maintaining data provenance of the individual parts of data merged as a result of the data processing (conflation) service. The client represents the encoding for provenance in a visual way ("tree" or network of data and services) adapted to distributed environments that that gives access to data or services instances (including processes) and their metadata records.

This deliverable is related to the following requirements:

- Allow general search capabilities
- Include Open Search for crowd-sourced data
- Allow ability to add metadata
- Demonstrate semantic mediation of aviation data
- Test and evaluate different encodings for OWS Context
- Allow to read and display OWS Context document
- Enable visual representation to support uncertainty and quality in mediation process
- Allow visual interaction for conflation and analysis
- Maintain the data provenance of processed data in metadata of new combined dataset
- Demonstrate semantic mediation of NGA, USGS, VGI, Commodity, etc.) as details in 5.2.1
- Demonstrate semantic mediation of aviation data

5.3.16 Single Point of Entry Global Gazetteer Engineering Report

Report shall include architecture of the system, best practices for services and for clients.

5.3.17 Web Feature Service 2.0 for USGS TNM

Web Feature to provide access to the USGS TNM Data

This deliverable is related to the following requirement:

- Include TDS, TNM, Open Street Map and VGI data

5.3.18 Web Feature Service 2.0 for NGA TDS

Web Feature to provide access to the USGS TNM Data

This deliverable is related to the following requirement:

- Include TDS, TNM, Open Street Map and VGI data

5.3.19 WFS-G for GNIS

Provide a WFS-G interface for GNIS.

This deliverable is related to the following requirements:

- Implement a WFS-G cascading service with semantic mediation capabilities
- Make available at least three geographic names databases via web services
- Revisit WFS standard for response completeness

- Implement service interface to query geographic names similar to current web interfaces
- Implement advance filter of query names
- Handle diacritics and special characters in searches
- Implement advance spatial constraints
- Implement advance gazetteer query services

5.3.20 WFS-G for GNS

Provide a WFS-G interface for GNS.

This deliverable is related to the following requirements:

- Implement a WFS-G cascading service with semantic mediation capabilities
- Make available at least three geographic names databases via web services
- Revisit WFS standard for response completeness
- Implement service interface to query geographic names similar to current web interfaces
- Implement advance filter of query names
- Handle diacritics and special characters in searches
- Implement advance spatial constraints
- Implement advance gazetteer query services

5.3.21 WFS-G semantic mediator

Provide a Semantic Mediator, which is also a WFS-G, capable of querying other WFSs and interacting with the SPARQL knowledge base.

This deliverable is related to the following requirements:

- Implement a WFS-G cascading service with semantic mediation capabilities
- Implement service interface to query geographic names similar to current web interfaces
- Implement advance filter of query names
- Handle diacritics and special characters in searches
- Implement advance spatial constraints
- Implement advance gazetteer query services

5.3.22 Catalog for Provenance

Catalog to register services and help discover them. It complements the Catalog for VGI. It supports the advance managing of data provenance in OGC Web Services.

This deliverable is related to the following requirements:

- Allow general search capabilities
- Allow ability to add metadata
- Investigate standard registration of SPARQL servers
- Investigate data quality exposure in OGC services and encodings

- Maintain the data provenance of processed data in metadata of new combined dataset
- Maintain link of process step and source

5.3.23 Client for Single Point of Entry Global Gazetteer

A client to demonstrate the Single Point of Entry of a Global Gazetteer.

This deliverable is related to the following set of requirements:

- Advance Single Point of Entry Global Gazetteer

5.4 CCI Enterprise Viewpoint

5.4.1 Semantic Heterogeneity

The advancement of technologies has allowed organizations to shift from providing static content and files over the web to providing web services. These services act as a gateway for providing more customized (e.g. processed) data to the users, and make it easier for clients to query and get the data that they need. The new challenge is to integrate and analyze vast volumes of data from these services to extract useful information.

OGC standards have helped in creating protocols and encodings for sharing geospatial data via web services. For example USGS National Geospatial Program (NGP) uses OGC web services to dynamically access geospatial data from The National Map and NGA uses OGC web services to access data based on Topographic Data Store (TDS) specifications.

Standards are often general and implementations of those standards may vary from community to community. As a result, meeting the challenge of integrating and analyzing vast volumes of data may require additional harmonization activities among communities interested in being interoperable. In particular the content models, dictionaries and code list vary form community to community.

Semantic heterogeneity can occur at the metadata level and at the data level. At the metadata level the different descriptions of data can differ from one metadata model to another. Semantic heterogeneity can occur within metadata elements (e.g. title, author) or within the actual values. For example, the values “stage height” and “water elevation” can both represent possible values for let’s say a metadata element “property-being-measured”.

Semantic heterogeneity can also occur at the data level. In this case the heterogeneity can occur at the conceptual level (UML) or at the actual representation of instances of the conceptual models. (XML).

An example of differences in the feature type “Dam” is presented in Figure 16.

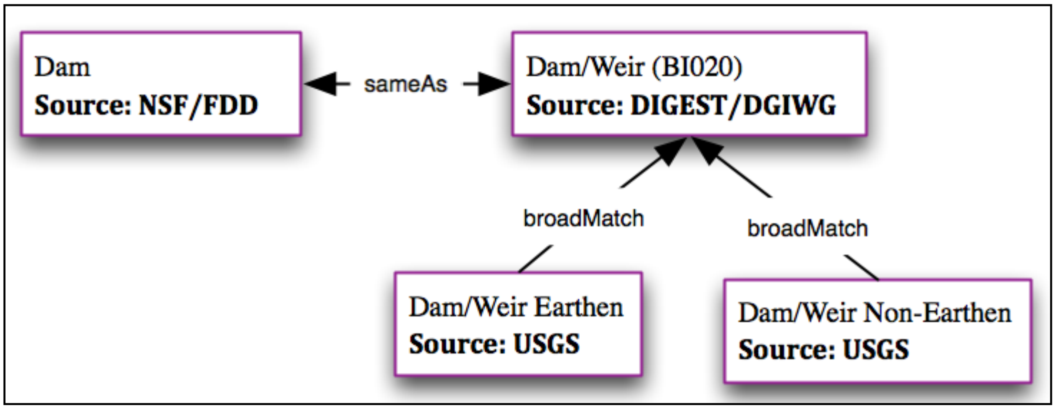

Figure 16. Example of the representation of the concept "Dam" in NSG, USGS and DIGEST

Assume that a user wants to retrieve all the dams from several data stores and portray the dams using USGS Symbology. The client can invoke several OGC services, such as WMS, WFS and WCS, to discover services, get data and get appropriate Symbology for the data presented. The system should be able reason about different feature types that exists in different data sources. However, even minor differences between these data models make it hard to integrate or even query both sets of holdings from a single interface. The client querying various data sources using the "Dam/Weir" feature type, define in DIGEST, should know that it requires to use the concepts "Dam/Weir Earthen" and "Dam/Weir Non-Earthen" when invoking USGS web service, as well as, using "Dam" when invoking NGA Web Services.

5.4.2 Gazetteer Interoperability

The US Government lacks a Single Point of Entry Global Gazetteer (SPEGG), where a user can submit a single query and access global geographic names data across multiple Federal names databases. This is a hindrance to military and civilian users who require access to names data both within and outside the United States. Currently users must make two queries with differing input parameters against two separate databases to obtain authoritative cross border geographic names data. Resolution of this issue will build on the semantic interoperability work of OWS–8, which addressed the differences between NGA's Topographic Data Store (TDS) to USGS's National Map (TNM) feature type data dictionaries.

The origins of the current situation are best understood by examining the evolution of the US Board on Geographic Names (BGN). The US Board on Geographic Names has two committees, the Domestic Names Committee and the Foreign Names Committee. The Domestic Names Committee, with its roots in the founding of the BGN in 1890, is responsible for names in the United States and its dependencies. The Foreign Names Committee, originating with the Public Law 80–242 in 1947, is responsible for names outside the United States.

The two committees independently developed names databases for recording names under their jurisdiction and these databases use different schemas and data dictionaries. The US Geological Survey (USGS) manages the Geographic Names Information System (GNIS), which was first developed in 1964, and currently contains information about domestic and Antarctic names. The National Geospatial- Intelligence Agency (NGA) manages the Geographic Names Data Base (GNDB) that is served to the public through the GeoNET Names

Server (GNS). The GNS has been in service since 1994. The GNS currently serves names for areas outside the United States and its dependent areas, as well as names for undersea features.

The most desirable solution from a Federal consumer's perspective would be a physically unified version of the two databases using a common coding scheme for the type of feature associated with the name. Currently, USGS recognizes 65 feature types, while NGA recognizes 680 feature types. USGS recognizes a single category for populated places, while NGA recognizes eight different types of populated place categories. This makes querying against both databases a challenge, as the user must understand and semantically map the feature types across databases. Given that the agencies are unlikely to physically unify their databases in the near future, the next best option would be to provide a SPEGG service founded on semantic mediation.

USGS and NGA have made strides towards this goal, most recently through the development of the ODNI-sponsored Web Feature Service – Gazetteer (WFS-G) standard development. This Open Geospatial Consortium (OGC) standard allows users to access geographic names data from differing geographic names databases using a common protocol. Users can access data from USGS and NGA using the single protocol, but still via separate requests to the databases.

WFS-G is not a SPEGG, but a building block upon which a SPEGG can be built. With the addition of a semantic mediation service to allow users to query using a single feature type (USGS, NGA, or a third solution combining both), the vision of a SPEGG is possible. The combination of semantic mediation and cascading servers would support access to both databases with a single request. Without a SPEGG, Federal users are driven to alternative non-authoritative solutions, like the GeoNames geographical database (http://www.geonames.org) or the Alexandria Digital Library (ADL) Gazetteer (http://www.alexandria.ucsb.edu/gazetteer/).

GeoNames is a non- global database created from NGA and USGS data (with other sources) and is enhanced by numerous web services for accessing the data. Both GeoNames and ADL have mapped USGS and NGA feature codes to a third feature coding standard, although the third feature coding standards differ. One of the NGA-sponsored mobile demonstrations at the recent GEOINT 2011 conference used GeoNames as the place names database, rather than the authoritative NGA or USGS sources, because of easier access to integrated global names and pre-existing services. Currently, when global names are required, users must merge the USGS and NGA database or access a non-authoritative global gazetteer. Merging the databases is time-consuming and costly, while accessing non-authoritative databases defeats the purpose of standardizing geographic names. This problem impacts all Government geospatial users whose mission covers both the United States and foreign nations and negatively affects access to authoritative geographic names.

The development of an SPEGG service will require the development of technologies and demonstrations in a number of areas, leading to the refinement and enhancement of existing Open Geospatial Consortium standards. It is anticipated that this will be done using a cascading web service, where the user submits a single query and multiple databases are queried. The primary obstacle to a SPEGG service is the lack of semantic interoperability between the dictionaries that define the feature types in the USGS and NGA gazetteers. This impacts common queries that include feature types parameters, i.e., find all populated places (PPLs) in country N.

5.4.3 Integration with Crowd-sourced data

Integration of data using OGC Services has been possible because the data have certain predefined structure. For example, feature data follow GML application schemas. But there is an emerging flow of less structure data provided by citizens (See Figure 17), that are becoming more and more important, and that requires to be integrated with structured data sources. This type of data will be refer to as crowd-sourced data.

Figure 17 – Crowd-Sourced Data

Crowd-sourced data can come from various inputs and can have different qualities. It can range from trusted expert to trusted volunteer to unknown volunteer to unwashed masses. The formats can vary from unattributed geolocation with unstructured text to some sort of structured, attributed geospatial information.

Volunteered Geographic information (VGI) is a subset of crowd-sourced information that complies to some semblance of data structure that might make it amenable to semantic mediation and conflation. VGI comes from both skilled and unskilled sources and may include crowds focused on specific problems or issues. Another emerging term is Volunteer Technical Community (VTC) which represents groups and individuals applying skills and efforts to emerging problems. VTC is most commonly associated with humanitarian assistance and disaster response. Several organizations are emerging to harness and focus VGI and VTC. This thread will investigate how to integrate this crowd-sourced data with data coming through standards to provide better information to the end user.

Example of crowd-sourced data includes:

- http://en.wikipedia.org/wiki/Volunteered_geographic_information
- http://www.gfdrr.org/gfdrr/volunteer-technology-communities-open-development
- http://giscorps.org/
- http://www.openstreetmap.org/
- http://www.disasterscharter.org/home
- http://crisiscommons.org/
- http://crisismappers.net/
- http://wiki.openstreetmap.org/wiki/Humanitarian_OSM_Team
- http://tomnod.com/
- http://wiki.crisiscommons.org/wiki/COD_101

- http://cod.humanitarianresponse.info/
- http://www.napsgfoundation.org/
- http://www.hifldwg.org/

5.4.4 Harmonization and previous activities

Semantic Harmonization is a process evolving different technologies to facilitate integration of heterogeneous data. In this context, the data is available, in most cases via well-defined web services and the semantics are exposed explicitly in a knowledge base. OGC Web Services and W3C Semantic Technologies can provide a powerful communication to provide geospatial data harmonization.

OWS-9 CCI advanced semantic mediation approaches to deal with differences in heterogeneous data models, including the automatic selection of proper symbology depending on the feature model being queried. It used the NGA TDS model and the USGS TNM model.

The approach used a Semantic Mediator server that took data from a single source server and transformed it to a specific other data model (See Figure 18). This way the semantic mediator acted as a WFS server. This made the mediation of data models transparent and easier to implement in clients.

To transform to and from TNM and TDS, an intermediate data model (Rosetta Mediation Model or RMM) was used based on the TDS data model. If other community were to participate, they needed only to map to the mediated model. All transformations from one data model to another happened by an intermediate transformation to the RMM data model. This means that for each data model supported by the semantic mediator, only transformations from that data model to the RMM data model need to be defined. This drastically reduces the amount of transformations defined when a large set of data models need to be supported in real-life applications.

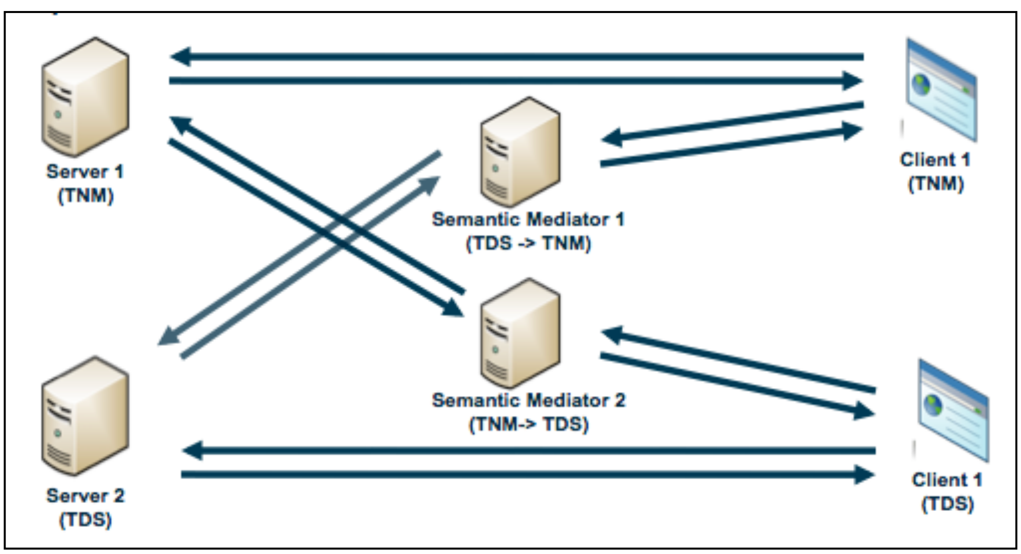

Figure 18. Semantic Mediator in OWS-9

Previous harmonization activities include the Geospatial One Stop (GOS) Transportation Pilot (GOS-TP) in 2003, in which four different data models were mapped into the FGDC Framework Transportation Layer.

5.4.5 Use Cases

Definitions:

Geographic Data: Data that is published in the web via OGC and non-OGC based services. It includes data available via Open Search and crowd-sourced data, as defined in 5.4.3. Geographic Data includes geometries, maps and multimedia (e.g. pictures and videos) data.

Actors:

- User
- Client – Usually a web application that the user interacts with
- Semantic Mediator – WFS server that gets queries, mediates them and translates them to other WFSs requests
- Conflation WPS server
- Knowledge Base (or SPARQL server) - holds mappings and rules
- WFS - A WFS Server with compliant OGC data
- Catalog
- Other Web Source: source for non traditional OGC source of data

The following is the summary of use cases:

1. Geographic Data – User Search
2. Geographic Data – Client Search
3. Geographic Data – Semantic Query Mediation
4. Geographic Data – Catalog VGI Harvesting
5. Geographic Data – User Analysis and Conflation
6. Single Point of Entry Global Gazetteer – User Search
7. Single Point of Entry Global Gazetteer – WFS Harvesting
8. Single Point of Entry Global Gazetteer – WFS-G mediation

Use Case Identifier: CCI #1	**Use Case Name**: Geographic Data – User Search
Use Case Domain: OWS-9 CCI	**Status**: Draft 2012-01-27
Use Case Description: User searches in a web client for Geographic Data	
Actors (Initiators): User	**Actors (Receivers):** User
Pre-Conditions: - User can access a web client - User is interest in general information related to a place of interest.	**Post-Conditions:** The user has discovered information for a place of interest.

System Components: - Web Client
Basic Course of Action: 1. User selects a region of interest in the Web Client 2. Web Client returns the most relevant results organized by different sources. The results contain metadata information about the source and provenance. Previous of the results are displayed properly depending in the type (video, text, geometric feature, image)

Use Case Identifier: CCI #2	**Use Case Name**: Geographic Data – Client Search
Use Case Domain: OWS-9 CCI	**Status**: Draft 2012-01-27
Use Case Description: User searches in a web client for Geographic Data	
Actors (Initiators): Client	**Actors (Receivers):** Client
Pre-Conditions: - User has performed a query on the client - Client is aware of the existence of semantic mediation	**Post-Conditions:** Client has query results from different sources including non-ogc data.
System Components: - Web Client - Semantic Mediator	
Basic Course of Action: 1. Client executes a query to the semantic mediator 2. Semantic Mediator responds with an aggregated response for the query.	

Use Case Identifier: CCI #3	**Use Case Name**: Geographic Data – Semantic Query Mediation
Use Case Domain: OWS-9 CCI	**Status**: Draft 2012-01-27
Use Case Description: Semantic Mediator interaction with client, knowledge base and data source	
Actors (Initiators):	**Actors (Receivers):**

<table>
<tr><td>Semantic Mediator</td><td>Semantic Mediator</td></tr>
<tr><td>Pre-Conditions:

- Semantic Mediator has received a query from the client
- Knowledge base contains rules and mappings that allows to translate the terms in the query from the client to terms to other services for proper query invocation</td><td>Post-Conditions:

Query result has been provided.</td></tr>
<tr><td colspan="2">System Components:

- WFS
- Semantic Mediator
- Knowledge Base</td></tr>
<tr><td colspan="2">Basic Course of Action:

1. Semantic Mediator invokes the knowledge base to get similar terms that are part of the query request (e.g. feature type) for a list of namespace (e.g. get similar concepts in the gnis ontology for rmm:Airport and get similar concepts in the gns ontology for rmm:Airport)
2. Knowledge Base respond with the information found (e.g. found gns: AIRP)
3. Semantic Mediator processes the results (translates RDF to WFS queries for each WFS server to be invoked)
4. Semantic Mediator queries each WFS based on the results from the Knowledge Base.</td></tr>
</table>

<table>
<tr><td>Use Case Identifier: CCI #4</td><td colspan="2">Use Case Name: Geographic Data – Catalog VGI Harvesting</td></tr>
<tr><td colspan="2">Use Case Domain: OWS-9 CCI</td><td>Status: Draft 2012-01-27</td></tr>
<tr><td colspan="3">Use Case Description: Catalog harvest data from VGI sources</td></tr>
<tr><td>Actors (Initiators):

WFS-other</td><td colspan="2">Actors (Receivers):

Client</td></tr>
<tr><td>Pre-Conditions:

- Catalog has been issued a query using an OpenSearch request for data in a particular region.</td><td colspan="2">Post-Conditions:

Client has received the query results for non OGC sources</td></tr>
<tr><td colspan="3">System Components:

- Catalog
- Other Web Sources
- Client</td></tr>
</table>

Basic Course of Action: 1. For each Other Web Source(s) the Catalog translates the query to a request that can be performed to each Other Web Source. 2. For each source the catalog performs a request to the Other Web Sources. 3. Catalog processes and aggregates the results. 4. Catalog responds to the Client following Open Search.

Use Case Identifier: CCI #5	**Use Case Name**: Geographic Data – User Analysis and Conflation
Use Case Domain: OWS-9 CCI	**Status**: Draft 2012-01-27
Use Case Description: Users performs qualitative analysis on data.	
Actors (Initiators): User	**Actors (Receivers):** Client
Pre-Conditions: - A client has presented some data with metadata to the user	**Post-Conditions:** User have a new data set where conflation issues has been resolved
System Components: - Conflation Service - Knowledge Base - Client	
Basic Course of Action: 1. User requests two solve conflation for two or more datasets 2. Client invokes the WPS conflation service 3. WPS invokes knowledge base to get mappings (e.g. mappings for feature types) and rules. 4. WPS processes sophisticated de-conflation algorithms 5. WPS responds to the client with a new data set, embedded metadata based on ISO 19115 about the process and with enough information (links, parameter inputs, etc.), for any client to be able to perform the same operation again.	

Use Case Identifier: CCI #6	**Use Case Name**: Single Point of Entry Global Gazetteer – User Search
Use Case Domain: OWS-9 CCI	**Status**: Draft 2012-01-27
Use Case Description: Both USGS GNIS and NGA GNS provide gazetteer data. A single entry point is required to access and mediate both sources. This use case presents the user	

<table>
<tr><td colspan="2">interaction with a web client</td></tr>
<tr><td>Actors (Initiators):

User</td><td>Actors (Receivers):

User</td></tr>
<tr><td>Pre-Conditions:

- User can access a web client single entry point.
- User needs to find a place of interest.</td><td>Post-Conditions:

Place of interest has been discovered.</td></tr>
<tr><td colspan="2">System Components:

- Web Client</td></tr>
<tr><td colspan="2">Basic Course of Action:

3. User chooses the type of information to query, which can be:
- Filtering by bbox
- Filtering by name, which can include diacritics (Starts With, Ends with, Contains, and Fuzzy Match)
- Filtering by administrative region
- Filtering by advance searches: closest feature type given a point, administrative hierarchy, feature elevation
4. User selected the source of data:
- Only GNIS
- Only GNS
- Mediated (via a third model)
5. Web Client processes the query
6. Web Client displays results to the user. Result should contain:
- Total numbers of records found by the Web Client in all the Sources
- Semantic Mapping Metadata: Description about any reasoning about the returned results. For example, if it involves a mediated query, it should return the type of mapping and any other indicator, such as “70% similar”.
7. User refines query based on results (back to step 1)</td></tr>
</table>

<table>
<tr><td>Use Case Identifier: CCI #7</td><td colspan="2">Use Case Name: Single Point of Entry Global Gazetteer – WFS Harvesting</td></tr>
<tr><td colspan="2">Use Case Domain: OWS-9 CCI</td><td>Status: Draft 2012-01-27</td></tr>
<tr><td colspan="3">Use Case Description: Both USGS GNIS and NGA GNS provide gazetteer data. A single entry point is required to access and mediate both sources. This use case presents the interaction of a web client with a server providing gazetteer data.</td></tr>
<tr><td>Actors (Initiators):</td><td colspan="2">Actors (Receivers):</td></tr>
</table>

Web Client	Web Client
Pre-Conditions: - Web Client is aware of WFSs providing gazetteer data - Enhanced WFS-G Semantic Mediator, is aware of GNIS and GNS WFS sources	**Post-Conditions:** Query result has been provided.
System Components: - Web Client - WFS-G (It can be the GNIS, GNS, or the enhanced WFS-G Semantic Mediator)	
Basic Course of Action: 1. Web Client queries on a WFS-G. The query should support the following: - Filtering by bbox - Filtering by name, which can include diacritics (Starts With, Ends with, Contains, and Fuzzy Match) - Filtering by administrative region - Filtering by advance searches: closest feature type given a point, administrative hierarchy, feature elevation 2. WFS-G responds to Web Client. Result includes: - Number of records found - Semantic Mapping Metadata	

Use Case Identifier: CCI #8	**Use Case Name**: Single Point of Entry Global Gazetteer – WFS-G mediation
Use Case Domain: OWS-9 CCI	**Status**: Draft 2012-01-27
Use Case Description: Both USGS GNIS and NGA GNS provide gazetteer data. A single entry point is required to access and mediate both sources. This use case presents the interaction of an enhanced WFS-G Semantic Mediator with other WFS-G services.	
Actors (Initiators): WFS-G	**Actors (Receivers):** WFS-G
Pre-Conditions: - Enhanced WFS-G Semantic Mediator, is aware of GNIS and GNS WFS sources - Enhanced WFS-G Semantic Mediator has received a query based on a intermediate (Rosetta mediation model or RMM)	**Post-Conditions:** Enhanced WFS-G has mediated gazetteer data form various WFS servers.

System Components:
- Web Client - Enhanced WFS-G Semantic Mediator - WFS-G for GNIS - WFSG for GNS - SPARQL Server
Basic Course of Action: 5. Enhanced WFS-G queries SPARQL server (knowledge base) to get similar feature types for a list of namespace (e.g. get similar concepts in the gnis ontology for rmm:Airport and get similar concepts in the gns ontology for rmm:Airport) 6. SPARL server responds (e.g. found gns: AIRP) 7. Enhanced WFS-G processes the results (translates RDF to WFS queries) 8. Enhanced WFS-G queries each WFS based on the results from the SPARQL server. 3. Each WFS-G (GNIS or GNS) Responds including: - Number of records found - Semantic Mapping Metadata 9. Enhanced WFS-G processes the results (merge, etc.)

5.5 CCI Information Viewpoint

The Information Viewpoint considers the information models and encodings that will make up the content of the services and exchanges to be extended or developed to support this thread. They are categorized based on the main purpose they served. More explanation about them is available in the reference section.

5.5.1 GML

Relevant Specification and Documents:

- *OGC 07-036 Geography Markup Language (GML) Encoding Specification 3.2.1* http://portal.opengeospatial.org/files/?artifact_id=20509

GML is an XML encoding for the transport and storage of geographic information, including both the geometry and properties of geographic features. GML is used for encoding data from WFS services.

5.5.2 GNIS

Relevant Specification and Documents:

- GNIS. http://nhd.usgs.gov/gnis.html

The U.S. Geological Survey in cooperation with the U.S. Board on Geographic Names developed the Geographic Names Information System (GNIS). It contains information about physical and cultural geographic features in the United States and associated areas, both current and historical (not including roads and highways). The database holds the Federally recognized name of each feature and defines the location of the feature by state, county, USGS topographic map, and geographic coordinates.

5.5.3 GNS

Relevant Specification and Documents:

- *GNS – GeoNET Names Server* http://earth-info.nga.mil/gns/html/

The GeoNET Names Server (GNS) serves the Geographic Names Data Base (GNDB) managed The National Geospatial- Intelligence Agency (NGA). It is the official repository of standard spellings of all foreign place names, sanctioned by the United States Board on Geographic Names. It has been in service since 1994, and serves names for areas outside the United States and its dependent areas, as well as names for undersea features.

5.5.4 Other Gazetteer Models

Relevant Specification and Documents:

- *ADL - Alexandria Digital Library Feature Type Thesaurus* http://www.alexandria.ucsb.edu/gazetteer/FeatureTypes/ver070302/index.htm
- *GeoName*s -http://www.geonames.org/

Other gazetteer models such as ADL and GeoNames, also provide source to geographic names . They have been developed outside the government.

In this testbed they will be used in conjunction with GNIS and GNS to be able to do demonstrated a Single Point of Entry Global Gazetteer*.*

5.5.5 RDF and OWL

Relevant Specification and Documents:

- Resource Description Framework (RDF): Concepts and Abstract Syntax. W3C Recommendation 10 February 2004. http://www.w3.org/TR/rdf-concepts/
- OWL Web Ontology Language. W3C Recommendation 10 February 2004. http://www.w3.org/TR/owl-features/
- OWL 2 Web Ontology Language. W3C Recommendation 27 October 2009. http://www.w3.org/TR/owl2-overview

RDF is a standard model for data interchange on the Web. RDF has features that facilitate data merging even if the underlying schemas differ, and it specifically supports the evolution of schemas over time without requiring all the data consumers to be changed. RDF extends the linking structure of the Web to use URIs to name the relationship between things as well as the two ends of the link (this is usually referred to as a “triple”). Using this model, it allows structured and semi-structured data to be mixed, exposed, and shared across different applications.

The OWL 2 Web Ontology Language, informally OWL 2, is an ontology language for the Semantic Web with formally defined meaning. OWL 2 ontologies provide classes, properties, individuals, and data values and are stored as Semantic Web documents. OWL 2 ontologies can be used along with information written in RDF, and OWL 2 ontologies themselves are primarily exchanged as RDF documents.

RDF can be used in this thread for encodings of models and mappings. The Ontology Web Language (OWL) is an extension of RDF, therefore can also be used. OWL 2.0 is richer than OWL 1.0. OWL 2.0 can better suit the needs to represent the data models.

5.5.6 Rule Interchange Format (RIF)

Relevant Specification and Documents:

- RIF Overview. W3C Working Group Note 22 June 2010. http://www.w3.org/TR/rif-overview
- W3C - RIF RDF and OWL Compatibility. W3C Recommendation 22 June 2010. http://www.w3.org/TR/rif-rdf-owl/

The W3C Rule Interchange Format (RIF) is a core rule language plus extensions, which together allow rules to be translated between rule languages and thus transferred between rule systems.

5.5.7 NGA Topographic Data Store (TDS) Model

Relevant Specification and Documents:

- NSG TDS Content Spec V2.0: https://nsgreg.nga.mil/as/view?i=82011
- NSG TDS Content Spec V3.0: https://nsgreg.nga.mil/as/view?i=82045
- NSG TDS Documentation: https://nsgreg.nga.mil/TopographicTerrestrial.jsp

The NSG TDS Content Specification specifies an extension to the NSG Entity Catalog (NEC) that: identifies specific content of the NEC that shall be obligatory for geospatial intelligence producers using this specification, and specifies the conditions under which this geospatial intelligence shall be collected by producers for use in net-centric data exchange with other NSG participants. The NEC specifies the domain data model for feature-based geospatial intelligence that determines the common semantic content of the NSG despite varying physical realizations across DoD/IC systems (i.e., regardless of whether geospatial features are represented as an image, a multi-dimensional grid of values, or a set of one or more vector shapes). The NSG TDS Content Specification identifies the topographic content of the Geospatial Intelligence Knowledge Base (GKB) that serves as the common DoD/IC virtual geospatial information environment on the Global Information Grid (GIG).

5.5.8 USGS National Map Data Model

Relevant Specification and Documents:

- USGS National Map. http://nationalmap.gov/
- USGS Transport Data Model. http://nationalmap.gov/transport.html
- USGS National Map Framework Web Feature Services. http://nationalmap.gov/framework.html

The National Map is a collaborative effort among the USGS and other Federal, State, and local partners to improve and deliver topographic information for the United States.

This Semantic Mediation subthread will use one or more of the data models from the National Map, for example the Transportation Data Model. USGS makes data based on this model accessible via the National Map Framework WFS.

5.5.9 ISO 19139 Metadata XML Schema Implementation

Relevant Specification and Documents:

- *ISO/TS 19139:2007 – Geographic Information – Metadata – XML Schema Implementation* http://www.iso.org/iso/catalogue_detail.htm?csnumber=32557

ISO/TS 19139:2007 defines Geographic Metadata XML encoding, an XML Schema Implementation derived from ISO 19115. It provides an encoding schema for describing, validating, and exchanging metadata about geographic datasets, dataset series, individual geographic features, feature attributes, feature types, feature properties, etc. It is conformant with OGC GML 3.2.1.

5.5.10 ISO 19115:2003

Relevant Specification and Documents:

- 19115:2003 *Geographic* Information – Metadata http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=26020

ISO 19115:2003 defines the metadata elements (and rules) for describing geographic information and service. It includes information about identification, the extent, the quality, the spatial and temporal schema, spatial reference, and distribution of digital data.

This specification will be used for descrying OCG services and data. However, it may possible be used to describe crow-sourced data .

5.5.11 ISO 19115-2:2009

Relevant Specification and Documents:

- 19115-2:2009 Geographic Information – Metadata – Part 2: Extensions for Imagery and Gridded Data http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=39229

ISO 19115-2:2009 extends ISO 19115:2003 by defining the schema required for describing imagery and gridded data, including the process. It provides information about the properties of the measuring equipment used to acquire the data, the geometry of the measuring process employed by the equipment, and the production process used to digitize the raw data. This extension deals with metadata needed to describe the derivation of geographic information from raw data, including the properties of the measuring system, and the numerical methods and computational procedures used in the derivation.

This specification will be used for descrying OCG services and data.

5.5.12 ISO 19157

Relevant Specification and Documents:

- The ISO/DIS 19157 Geographic Information – Data Quality http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=32575

ISO/DIS 19157 provides the principles for describing the quality for geographic data and concepts for handling quality information for geographic data. It provides a standard manner to determine and report a dataset's quality information. It also includes guidelines for evaluation procedures of quantitative quality information for geographic data

This specification will be used in the thread for the advancing the management of data provenance in OGC services (See section 5.2.6).

5.6 CCI Computational Viewpoint

The computational viewpoint is concerned with the functional decomposition of this thread architecture into a set of services that interact at interfaces. It reflects the components, interfaces, interactions and constraints of the service architecture without regard to their distribution.

5.6.1 Web Feature Service / Filter Encoding

Relevant Specifications:

- *OGC 09-025r1 and ISO/IEC FDIS 19142:2010 Geographic information - Web Feature Service* http://www.opengeospatial.org/standards/wfs
- *ISO 19143:2010 Filter Encoding Implementation Specification 2.0; Geographic Information – Filter Encoding* (http://www.isotc211.org/protdoc/211n2633/; final version submitted to ISO also available on OGC Pending Documents page at http://portal.opengeospatial.org/files/?artifact_id=32680&version=1)

The purpose of the WFS is to describe data manipulation operations on OGC Simple Features (feature instances) such that servers and clients can "communicate" at the feature level. WFS servers normally apply an application schema or profile of GML for the payload. WFS allows a client to retrieve and update geospatial data encoded in (GML) from multiple WFSs. It defines interfaces for data access and manipulation operations on geographic features, using http as the distributed computing platform.

The FE is an XML encoding for filter expressions. A filter expression logically combines constraints on the properties of a feature in order to identify a particular subset of features to be operated upon. For example, a subset of features might be identified to render them in a particular color or convert them into a user-specified format. Constraints can be specified on values of spatial, temporal and scalar properties.

WFS 2.0 and FES 1.1 will be used to serve and query data from the different data models.

5.6.2 Web Feature Service – Gazetteer

***Relevant Specification and Documents**:*

- WFS-G – Gazetteer Service - Application Profile of the Web Feature Service Candidate Implementation Standard (1.0) 11-122r1 RFC https://portal.opengeospatial.org/files/?artifact_id=46964

The WFS-G web service allows a client to search and retrieve elements of a geo-referenced vocabulary of well-known place-names. The WFS Gazetteer Profile is an Application profile of WFS. Published as a best practice document in 2011. It implements a more comprehensive set of elements from the "Spatial referencing by geographic identifiers" (ISO 19112) that defines an abstract model to be implemented by a gazetteer service

5.6.3 Web Feature Service Semantic Mediator

This OGC WFS Semantic Mediator, as develop in WOS-8, is component is capable of:

- A WFS.
- Translating between instances of domain models in GML and RDF.
- A client to a Catalog via CSW for discovering services
- A client of the knowledge base, capable of semantic querying over a knowledge base (Common ontology + domain ontologies + rules + mappings).

5.6.4 Catalog Services

Relevant Specifications and Documents:

- *OGC 07-006r1 - OGC Catalog Service Implementation Specification (CSW) 2.0.2* http://portal.opengeospatial.org/files/?artifact_id=20555
- *OGC 10-127r1 – OWS-7 Aviation Portrayal Engineering Report* http://portal.opengeospatial.org/files/?artifact_id=40134
- *OGC 07-110r4 - CSW-ebRIM Registry Service - Part 1: ebRIM profile of CSW* http://portal.opengeospatial.org/files/?artifact_id=31137

The OGC Catalog Service for the Web (CSW) supports the ability to publish and search collections of descriptive information (metadata) for data, services, and related information objects. Metadata in catalogs represent resource characteristics that can be queried and presented for evaluation and further processing by both humans and software. The Catalog Service supports the discovery and binding to these registered information resources within an information community.

The CSW-ebRIM Registry Service is a profile of the CSW. It applies the CSW interfaces to the OASIS ebXML registry information model (ebRIM 3.0). CSW-ebRIM provides a general and flexible web-based registry service that enables users—human or software agents—to locate, access, and make use of resources in an open, distributed system; it provides facilities for retrieving, storing, and managing many kinds of resource descriptions.

5.6.5 OpenSearch

Relevant Specifications and Documents:

- *OpenStreetMap*
  Wikiguide http://wiki.openstreetmap.org/wiki/Beginners_Guide_1.1
  OpenSearch Geo 1.0
  http://www.opensearch.org/Specifications/OpenSearch/Extensions/Geo/1.0/Draft_1

OpenSearch provides the mechanism to publishing search results in a simple format suitable for syndication and aggregation. The OpenSearch Geo extension is an extension of OpenSearch and allow to query by geospatial extend (bbox) and geographic name. Returned results are based on GeoRSS.

OpenSearch Geo Query Interface was approved by the OGC Technical Committee (November 2011) to use the Fast Track process to become an OGC Candidate Standard. It may also be part of the CSW 3.0 standard

5.6.6 OGC GeoSPARQL

Relevant Specifications and Documents:

- OGC 11-*052r4* - OGC GeoSPARQL - A Geographic Query Language for RDF Data

This standard defines a set of SPARQL extension functions, a set of RIF rules, and a core RDF/OWL vocabulary for geographic information based on the General Feature Model, Simple Features, Feature Geometry and SQL MM.

This standard will be used by the semantic mediator an d by the knowledge base to perform semantic mediation

5.7 CCI Engineering Viewpoint

The Enterprise, Information, and Computation viewpoints describe a system in terms of its purposes, its content, and its functions. The Engineering viewpoint identifies component types in order to support distributed interaction between the components of the system. Those components interact based upon the services identified and described in the Computational viewpoint. Figure 19 provides an overview of the components of this thread, organized based on the ISO 3 tier model with the top tier dealing with clients, the middle tier embodying the business processes required to respond to requests issued by clients, and a lower tier focusing on read/write access to data.

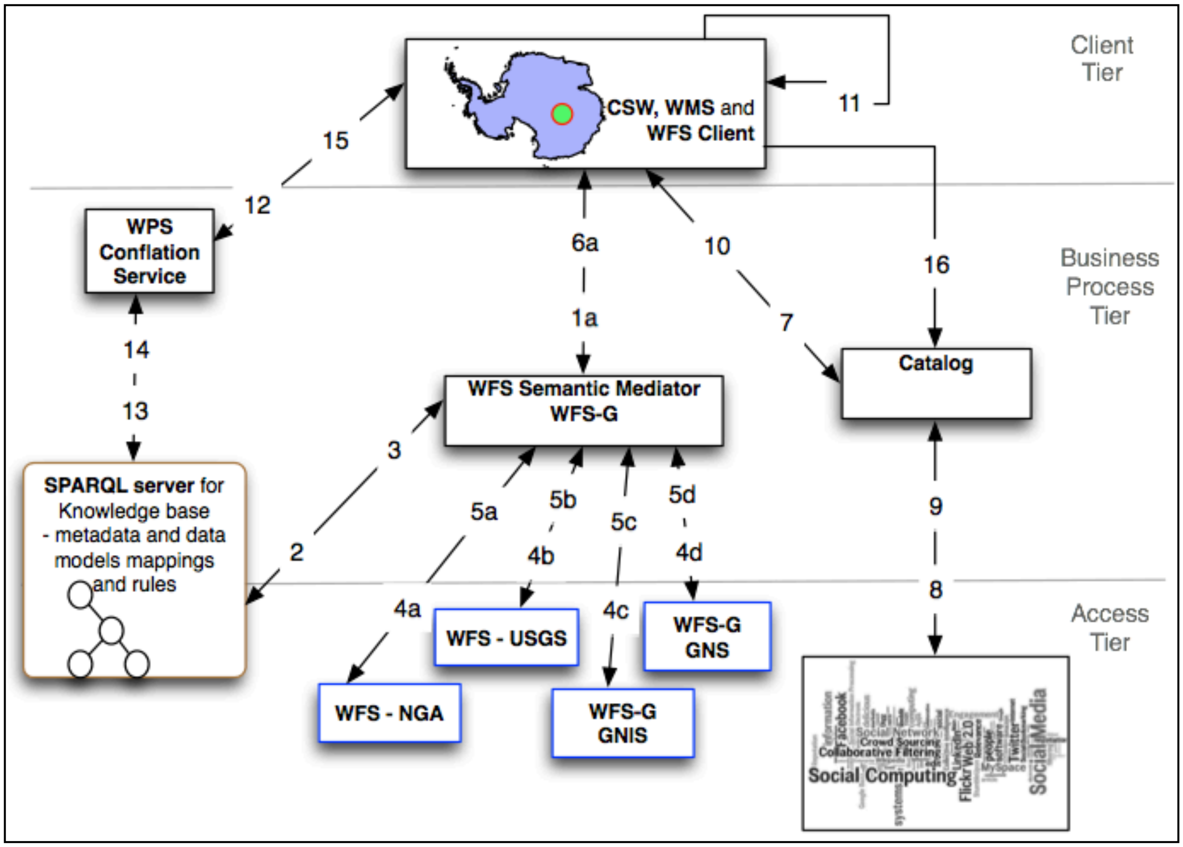

Figure 19. Overview of Components in CCI Thread

The diagram shows the main components of the CCI Thread for OWS-9. It shows the main interactions among the components. For simplification purposes, the initial registration of the components to the catalog and the discovery of the services by the client using the catalog are not shown.

1. Client queries the semantic mediator based on a simple common model
2. Semantic Mediator translates WFS queries into ontology queries and performs a SPARQL query to the knowledge base.
3. The knowledge base responds translations of the semantics of the query to other models (e.g. WFS NGA model)
4. The semantic mediator invokes the WFS services
5. The WFS services respond with data or metadata.

6. WFS Semantic Mediator responds an aggregated WFS respond based on the simple common model.
7. Client also invokes a Catalog where via Open Search is able to access VGI (crowd-sourced) data.
8. Catalog searches on selected VGI sources.
9. Source via special APIs or through HTTP (web content) or Rest interfaces provide the catalog with appropriate information.
10. Catalog responses to client.
11. User views metadata, previous and decides to do conflation of two or more resources.
12. Client invokes a WPS conflation service.
13. Conflation Service may invoke the knowledge base to get more information about the data sources.
14. Knowledge base responds with semantic similarities information.
15. Conflation Service responds with a new data set with embedded metadata about the process and with enough information (links, parameter inputs etc..) to be able to perform the same operation again. User can then perform more analysis, can add metadata and can invoke again the WPS conflation service.
16. User can publish the result into a catalog.

6 OWS-9 Thread: Security and Services Interoperability (SSI)

6.1 SSI Thread Scope

The OWS-9 SSI thread contains 5 major objectives. Security Management, GML Application Schema UGA Updates, Web Services Façade, Reference Architecture Profiling, and Bulk Data Transfer. Each of these objectives are described in greater detail below:

- **Security Management:** Builds on and extends on the OWS-6 Security thread. Security management will be based on WS-Federation for Web service (SOA) transactions. Authentication and authorization functionality will include role-based and attribute-based rules indicating where a user and SOA Consumer is authorized access to particular services or particular data content.
- **GML Application Schema UGAS updates:** Builds on the OWS-9 Schema Automation activity for improved schema automation supporting SWE common 2.0 with an open source UML-to-GML Application Schema (UGAS) tool. Add - UML to JSON capabilities.
- **Web Services Façade:** Builds a tool for web service developers to implement as a façade to the service capable of translating a request from one binding format into a binding format which is supported by that OWS service
- **Reference Architecture Profiling:** Evaluates the content of the IC/DoD Content Discovery and Retrieval Reference Architecture against the OGC Reference Architecture incorporating ideas and content as appropriate.
- **Bulk Data Transfer:** Loosely builds upon the OWS-9 GeoSync activity investigating data transfer. This objective will explore streaming solutions, and real time data updates to be usable on in conjunction with any devise, while ensuring data integrity and precision.

6.2 SSI Thread Requirements

6.2.1 Security Management Requirements

References:

- NIST 800-63, csrc.**nist**.gov/publications/**nist**pubs/**800-63**/SP**800-63**V1_0_2.pdf
- *Security Assertion Markup Language (1.1 and 2.0)- OASIS Standard* http://saml.xml.org/saml-specifications
- *XACML 2.0 – OASIS Standard* http://www.oasis-open.org/specs/#xacmlv2.0
- *GeoXACML OGC 07-026r2* - http://www.opengeospatial.org/standards/geoxacml
- *OWS-6 Security Engineering Report OGC 09-035* http://portal.opengeospatial.org/files/?artifact_id=35461
- WS-Security v1.1
- WS-Trust v 1.3
- WS-Policy
- WS-ReliableMessaging
- WS-Federation
- XML Digital Signature

- XML Encryption
- OWS-4 Trusted GeoServices (OGC 06-107r1)
- OWS-4 GeoDRM Engineering Viewpoint and supporting Architecture (OGC 06-184r2)
- Geospatial Digital Rights Management Reference Model (GeoDRM RM) (OGC 06-004r3)
- ISO 15000, 15408, 15443, 10181

Authentication and authorization within a SOA environment applies both to (a) the user's access to a user-facing application or application interface (like a portal for example) as well as (b) authorization for a Web service transaction to be executed by the target Web service. This requires the ability to define role-based and attribute based rules indicating where both a SOA Consumer (i.e., the client system) and its associated user are authorized access to particular services or particular data content. Access controls shall be capable of including or excluding access to the granularity of a single user. Security token content within the SOA transaction messaging will include both use and SOA Consumer assertions to permit the desired access granularity to be based on both sets of information. Access permission to an object by users and/or SOA Consumers not already possessing access permission shall only be assigned by authorized users. The participant shall demonstrate a method by which a temporary authorization may be granted.

The participant shall build on OWS-6 security framework to provide an Identification and Authentication (I&A) management mechanism that ensures a unique identifier for each user and SOA Consumer and that associates those identifiers with all auditable actions taken by the user and the SOA Consumer on behalf of the user. Identification and Authentication (I&A) Account Management procedures include:

a. Identifying types of accounts (individual and group, conditions for group membership, associated privileges).
b. Establishing an account.
c. Activating an account.
d. Modifying an account (e.g., disabling an account, changing privilege level, group memberships, authenticators).
e. Terminating an account (i.e., processes and assurances).

The participant shall investigate and demonstrate the ability to provide auditing capabilities. Audit Trail to include:

a. Providing the capability to ensure that all audit records include enough information to allow the information security officer to determine the date and time of action (e.g., common network time), the system locale of the action, the system entity that initiated or completed the action, the resources involved, and the action involved.

b. Protecting the contents of audit trails against unauthorized access, modification, or deletion.
c. Maintaining collected audit data at least 5 years and reviewing at least weekly.
d. The system's creating and maintaining an audit trail that includes selected records of:

    i. Successful and unsuccessful logons and logoffs.
    ii. Accesses to security-relevant objects and directories, including opens,

iii. closes, modifications, and deletions.

This objective seeks evaluation of the process for developing rules and service support for rules creation, storage and re-use. Of particular interest is developing or recommending an existing rules encoding standard, in particular GeoXACML or XACML 3.0 and a service that could "translate" rules that have been created using many different techniques (SQL scripts, XML, GeoXACML, SAML, proprietary methods) into a rules-in-standard-format encoding. The participant shall develop or recommend a common rules-in-standard-format encoding for rules with mappings between current widely implemented techniques for rules. The participant shall develop a prototype service capability for the creation, storage and re-use of rules. This objective is interested in ensuring these rules are compatible with an Oracle repository for housing and managing rules.

The participant shall evaluate previous testbed activities which tested evaluated and implemented security for OGC services and apply appropriate constraints based on the authentication and authorization rules identified for the consumer of the query results. In addition to previous work accomplished in the area of service security the participant shall consider the following requirements and implementation options:

a. Some process or mechanism(s) that allows users to determine the formal access approvals (e.g., compartments) for which the user is allowed access.
b. Some process or mechanism(s) that allow users to determine the sensitivity level (i.e., classification level, classification category, and handling caveats) of data.
c. Some process or mechanism(s) that allow or restrict user's access based on the sensitivity level (i.e., classification level, classification category, and handling caveats) of data.
d. Some process or mechanism(s) that allows or restricts user's access based on role based rules identifying the user's authorization level to service, dataset, layer, feature and/or attribute levels.
e. Some process or mechanism that allows or restricts user's access based on ABAC (Attribute Based Access Control). That is, access based on attributes associated with the user. This is meant to apply to both browser-based transactions as well as those that are Web services (SOA) based.

Implementation and demonstration requirements:

a. HTTP POST with SAML
b. SOAP
c. GeoXACML
d. Shibboleth

Identity Federation. For browser-based operations, where perhaps a user initiates access to a portal and triggers an action whereby the portal becomes a SOA Consumer and kicks-off a Web service transaction, consider the use of multiple types of industry standard identity federation profile and implement at least one. An OASIS Web Browser SSO Profile would be desirable with security token content contained in the HTTP (or HTTPS) POST. The alternative is to use direct authentication to the portal or equivalent.

Metadata on the target Web services. WSDL will be used and will include policy information or point to the policy information. Policy metadata will preferably be in WS-Policy and WS-Security Policy format. Contents include security tokens required, attribute content of the tokens, specification on encryption use, digital signature use, crypto algorithms, etc. In OWS9 the use of this set of metadata will likely be manual, at least in part, but preparation for automated use in future OWS investigations is expected to be one objective.

Authentication. As explained earlier, authentication at the user-facing application as well as authentication at or on behalf of the target Web service are both within scope for this testbed. Throughout this task make allowance for different types of user authentication, ranging from LOA 1 (NIST 800-63) up through LOA 4. All types need not be demonstrated. Where appropriate, such as within the use of SAML assertions, consider an optional expansion of the demonstration to include authentication context information (via SAML) including its use as part of the authorization decision-making. Demonstrating Holder of Key for confirmation method would be a plus but is not required. Authentication (and authorization) for a Web service will require the transaction messaging to contain security tokens covering both the user as well as the SOA Consumer.

SOA Authorization / Access Control. Demonstrate access control for SOA environments based on WS-Federation (active) principles for the operations of the transaction. The general orientation with SOAP, WS-Security, SAML security tokens, and metadata description of services. While allowing for potential use of the various transport-level, message-level, and security token-level security (encryption and digital signature) is the goal and should be available as an option, the use of all simultaneously is not necessarily expected for OWS9. Actual WS-Federation technical content in demonstrated implementations can be based on an interpretation by the participant of what is needed to achieve the functional objectives.

Security Tokens. It is expected that SAML version 2.0 Core (assertions) will be used throughout this task as the security token, although others may be additionally included if the participant desires. The use of an STS (WS-Trust) for security token creation and validation is now a common industry practice and to be encouraged, but is not mandatory within OWS9.

Access Management Technology. Consider the use of both XACML and GeoXACML and if it is decided to settle on only one for implementation purposes please explain the reasons.

Message & Token Security. Allow for end-to-end security of both the security tokens and of message content. For SAML that would be an option to use digital signatures (XML-DSIG) and/or encryption (XML-ENC). The same for message-level content with the use of WS-Security for the SOAP WS-star environment. Demonstrations could be partial, such as showing digital signature integrity with SAML and WS-Security but not including encryption.

Transport Level. Demonstrations will include use of SSL/TLS. Mutual SSL/TLS should be available as an option. This is not considered to be the end-to-end security as covered in the preceding paragraph (due to load balancers, hardware accelerators, ESBs, etc.) but SSL/TLS still provides a reasonable measure of security protection.

6.2.2 GML Application Schema UGAS Requirements

References:

- JSON Schema (IETF draft-zyp-json-schema-03; http://tools.ietf.org/html/draft-zyp-json-schema-03)
- JsonML (http://www.ibm.com/developerworks/library/x-jsonml/)

- ISO 19136; http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=32554
- SWE Common 2.0; http://www.opengeospatial.org/standards/swecommon
- ISO 19139; www.iso.org/iso/catalogue_detail.htm?csnumber=32557

The goal of this subtask is to build on the OWS-9 Schema Automation activity for improved schema automation supporting SWE Common 2.0 with as open source UML-to-GML Application Schema (UGAS) tool (such as ShapeChange) as used with the U.S. National System for Geospatial Intelligence (NSG) Application Schema (NAS) and associated NSG Metadata Foundation (NMF) Implementation Specification (NMIS).

In SWE Common 2.0 the derivation from GML has been improved by making all elements substitutable for GML AbstractValue (and thus transitively for GML AbstractObject) so that they can be used directly by GML application schemas. The GML encoding rules as defined in ISO 19136 have also been used to generate XML schemas from the UML models with only "minor modifications".

SWE Common 2.0 defines extensions to the rules specified in ISO 19136 to allow:

- Use of "soft-typed" properties. These properties are encoded as XML elements with a generic element name but provide a "name" attribute for further disambiguation.
- Encoding of certain properties as XML attributes. This type of encoding adds to the "element-only" rules defined by ISO 19136. It is restricted to properties with a primitive type and indicated by a new tagged value in the UML model.
- Use of a new abstract base type. A custom base type called "AbstractSWEType" is used for all complex types.
- Each UML class with a <<Type>> or <<DataType>> stereotype, or no stereotype at all, is implemented in the schema as a global XML complex type with a corresponding global XML element (called object element). Each of these elements has the same name as the UML class (i.e. always UpperCamelCase) and the name of the associated complex type is a concatenation of this name and the word "Type".
- Each UML class attribute is implemented either as a global complex type and a corresponding local element (called property element), or as an XML attribute. Each property complex type is given a name composed of the UML attribute name (always lowerCamelCase) and the words "PropertyType". The element is defined locally within the complex type representing the class carrying the attribute and named exactly like the attribute in UML (i.e. no global elements are created for class attributes). Class associations are implemented similarly except they cannot be implemented as an XML attributes.

This objective seeks to explore the generation of JSON Schema (IETF draft-zyp-json-schema-03; http://tools.ietf.org/html/draft-zyp-json-schema-03) – or alternative means such as JsonML (http://www.ibm.com/developerworks/library/x-jsonml/) – for specifying JSON-based data exchange structures from UML using the UGAS approach. Possible contexts in which to conduct this investigation are SWE Common 2.0 and/or ongoing work in the GeoServices REST API SWG.

6.2.3 Web Service Facade Requirements

References:

- WFS GetCapabilities document; portal.opengeospatial.org/files/?artifact_id=8339

OGC web services can be developed in such a way that they are fully compliant with the standard but still pose interoperability issues. One such case is in the selection of bindings supported by a web service. If the client and server do not use the same binding, they will not interoperate. A service will define which binding it supports as part of its GetCapabilities document. If a client requests information from the server via a different binding than the server supports, the server typically returns an error message that would not necessarily be useful to the client. If, for example, a WFS server provides for a HTTP POST binding and a client makes the request using a SOAP binding an interoperability issue exists. It is possible however, to require a developer to implement a "façade" on the server side which would be able to read a request and interpret it or translate it to a binding it does support to solve such interoperability problems.

To alleviate this problem, a tool is needed for web service developers to implement as a façade to the service capable of translating a request from one binding format into a binding format which is supported by that service. OGC will investigate the development of an open source Bindings Façade Tool that supports the translation between bindings currently supported by OGC Web Services: KVP (GET and POST) and SOAP (HTTP POST). OGC will investigate whether this "tool" is better suited as a client side or service side solution.

6.2.4 Reference Architecture Profiling Requirements

References:

- OGC Reference Model; portal.opengeospatial.org/files/?artifact_id=3836
- IC/DoD Content Discovery and Retrieval Reference Architecture; https://metadata.dod.mil/mdr/.../DoDMWG/2010/.../2010-04-13_CDRIPT.ppt

The participant shall evaluate the content of the IC/DoD Content Discovery and Retrieval Reference Architecture against the OGC Reference Architecture incorporating ideas and content as appropriate.

The participant shall work with OGC staff who will provide HTML web access to the OGC Reference Model. The OGC Reference Model includes adding new standards, updating the current version on standards that have been moved to newer versions, and enabling HTML-based web access to the document paragraph by paragraph so that user communities can easily review, extract, derive, supplement and reorganize the content to better suit their internal documentation requirements.

The participant shall work with OGC staff who will web-enable the OGC Reference Architecture and build a GUI such that a community of interest could derive and build a profile of suitable OGC standards to meet their specific needs. This shall be done in such a way as to provide a knowledge base that would identify when or what standards are required based on a users defined implementation requirement. For example if a use case were defined as portrayal of feature data in a map-like environment the knowledge base should be able to define the roles and interface requirements for WFS, WMS with FPS, SLD, SE, KML, OWS Common, etc. This should take into account any dependency between different standards. Community of Interest Profiles shall be downloadable in a number of standard formats such as Excel, MS Word or PDF.

6.2.5 Bulk Data Transfer Requirements

References:

- OWS-9 Geodata Bulk Transfer with GML/WFS ER; https://portal.opengeospatial.org/files/?artifact_id=46679
- OWS-9 Geodata Bulk Transfer with FileGDB ER; https://portal.opengeospatial.org/files/?artifact_id=45754
- OWS-9 Best Practices for Use of Geosynchronization ER; https://portal.opengeospatial.org/files/?artifact_id=46037
- OWS-9 GSS CR for WFS; https://portal.opengeospatial.org/files/?artifact_id=46038.
- MSDN Large Data and Streaming; http://msdn.microsoft.com/en-us/library/ms733742.aspx

Builds upon the OWS-9 activity to advance the ability to transfer data sets in a consistent manner to multiple platforms as well as supporting offline or over limited bandwidth networks. Past initiatives with OGC we able to prove two solutions using the ArcGIS native format File Geodatabase (FGDB) and open source PostGIS were capable of bulk data transfer. This objective will investigate utilizing GML streaming to perform data transportation and real time imagery updates. The use of GeoJSON streaming maybe alternatively explored vs. GML. The prototype will only require demonstration of one of the technologies. Ensuring speed, precision and accuracy of the data. The potential use of Spatialite to store the data for visualization or exploitation on the client side, should be considered in as a piece of this prototype.

The strategy to deal with large payloads is streaming. While messages, especially those expressed in XML, are commonly thought of as being relatively compact data packages, a message might be multiple gigabytes in size and resemble a continuous data stream more than a data package. When data is transferred in streaming mode instead of buffered mode, the sender makes the contents of the message body available to the recipient in the form of a stream and the message infrastructure continuously forwards the data from sender to receiver as it becomes available.

The most common scenario in which such large data content transfers occur are transfers of binary data objects that:

- Cannot be easily broken up into a message sequence.
- Must be delivered in a timely manner.
- Are not available in their entirety when the transfer is initiated.

For data that does not have these constraints, it is typically better to send sequences of messages within the scope of a session than one large message.

6.3 SSI Thread Deliverables

The Deliverables are summarized in the Table with descriptions of the Deliverables in paragraphs following the table.

Table 3 – SSI Thread Deliverables Summary

1. OWS-9 SSI Web Service Security ER
2. OWS-9 SSI Security Rules Service ER
3. OWS-9 SSI UGAS Engineering Report
4. OWS-9 SSI Bulk Data Transfer Streaming Investigation ER
5. OWS-9 SSI CDA Reference Architecture Analysis ER
6. OWS-9 SSI Bindings Façade Tool ER (in-kind)
7. Suite of Security Services
8. Security Common Rules Encoding
9. Security Rules Prototype Service
10. Security Services Implementation Prototype
11. Upgraded UGAS tool - SWE Common 2.
12. Upgraded UGAS tool - UML to JSON schema encoding
13. Prototype(s) of OWS Bindings Façade Tool
14. Bulk Data Transfer Prototype

6.3.1 OWS-9 SSI Web Service Security Engineering Report

This ER shall take into account all previous OGC testbed and IE work accomplished as well as capture the results of this testbed. This ER shall include but not necessarily be limited to sections describing the pro and con of each potential solution for each potential operating environment (SOAP, REST, Mobile, etc.)

6.3.2 OWS-9 SSI Security Rules Service Engineering Report

OGC Rules Service Engineering Report as defined in section 6.2.1

6.3.3 OWS-9 SSI UGAS Engineering Report

Report documenting the UGAS formal-update-releasable v1.0 as defined in section 6.2.2

6.3.4 OWS-9 SSI Bulk Data Transfer Streaming Investigation Engineering Report

Explore the pros and con of utilizing GML Streaming for real-time bulk data updates. Document the API for the prototyped protocol, capture client side solutions required to render, edit data updates and offer recommendations for future enhancements; as defined in section 6.2.5

6.3.5 OWS-9 SSI CDA Reference Architecture Analysis Engineering Report

This ER documents the IC/DoD Content Discovery and Retrieval (CDA) Reference Architecture comparing against the OGC Reference Architecture as described in section 6.2.4

6.3.6 OWS-9 SSI Bindings Façade Tool Engineering Report

Document detailing implementation and usage for the Façade tool as described in section 6.2.3. This could also be achieved by documentation on the open source repository for the Facade Tool. (There is no funding for this deliverable.)

6.3.7 Suite of Security Services

A suite of services to support Authentication, Authorization, Audit, and the communications and management types of security covered in section 6.2.1 such as embodied with WS-Security, WS-Security Policy, WS-Trust, and SAML Core.

6.3.8 SSI Security Common Rules Encoding

A service to provide a common rules-in-standard-format encoding with mappings between current widely implemented techniques for rules, as described in section 6.2.1.

6.3.9 Security Rules Prototype Service

Prototype Rules Service providing for rules creation, storage and re-use as described in section 6.2.1.

6.3.10 Security Services Implementation Prototype

Prototype Service implementations to evaluate the differing service interfaces, rules encodings and security methods, as described in section 6.2.1.

6.3.11 Upgraded UGAS tool - SWE Common 2.

A UGAS Open Source tool to support SWE Common 2 as described in section 6.2.2.

6.3.12 Upgraded UGAS tool - UML to JSON schema encoding

A UGAS UML Open source tool to support UML to JSON schema encoding (SWE Common 2.0 and/or GeoServices REST API) as described in section 6.2.2.

6.3.13 Prototype(s) of OWS Binding Façade Tool

An open source tool for web service developers to implement as a façade to the service capable of translating a request from one binding format into a binding format which is supported by that service as described in section 6.2.3.

6.3.14 Bulk Data Transfer Prototype

Demonstrate the transfer of data, exploring GML streaming technologies. Ensuring data speed, precision and accuracy are checked and maintained, as well as the data is usable real-time (renderable) from the client receiving the updates.

6.4 SSI Enterprise Viewpoint

6.4.1 Security Management Enterprise Viewpoint

Service Security is a growing problem and concern worldwide as more and more data becomes available via the internet the need to protect that data from unauthorized users becomes a higher concern. The security management objective investigates how to ensure data security without limiting those who need open unrestricted access using the same OGC compliant services.

Web services security is founded on the following concepts that have been discussed earlier in terms of implementation requirements in section 6.2.1:

Authentication: Who is accessing the resource? Verify that principals (humans or application components) are who they claim to be through appropriate proof of identity. Determine the identity or role of a party attempting to perform some action, such as accessing a resource or participating in a transaction.

Authorization: What can they do? Grant permission for principals to access resources based upon access rights. Determine whether some party is allowed to perform a requested action or access particular resources.

Integrity: Ensure that information is intact. Ensure that information is not changed in transit, either due to malicious intent or by accident. This may be information transmitted over a network, information stored in a database or file system, or information passed in a Web services message and processed by intermediaries.

Non-repudiation: Verify the identity of authors using electronic signatures. Produce or verify an electronic signature for purposes such as approval, confirmation of receipt, acceptance or agreement.

Confidentiality: Make content unreadable by unauthorized parties. Ensure that only legitimate parties may view content, even if other access control mechanisms are bypassed, and guarantee that exchanged information is protected against eavesdroppers. Confidentiality is generally associated with encryption technologies.

Privacy: Limit access and use of individually identifiable information. Personally identifiable information is required by individuals and organizations to perform services for an individual.

6.4.2 GML Application Schema UGA Viewpoint

Standards are often general and implementations of those standards may vary from community to community. As a result, meeting the challenge of integrating and analyzing vast volumes of data may require additional harmonization activities among communities interested in being interoperable.

One strategy that can improve interoperability among communities is to advance schema automation based on conceptual models. Communities will only deal with creating their conceptual (UML) models. Languages such as OCL help specify application schemas.

6.4.3 Web Services Facade Enterprise Viewpoint

One of the fundamental goals when designing service-oriented solutions is to attain a reduced degree of coupling between services, thereby increasing the freedom and flexibility with which services can be individually evolved. Achieving the right level of coupling "looseness" is most often considered a design issue that revolves around the service contract and the consumer programs that form dependencies upon it.

However, for the service architect there are opportunities to establish intermediate layers of abstraction within the service implementation that further foster reduced levels of coupling between its internal moving parts so as to accommodate the evolution and governance of the service itself. These intermediate abstraction layers are created by the application of Service Façade, a design pattern focused on intra-service design.

When designing a service, there are several negative coupling types you need to look out for. Contract-to-logic coupling, for example, results in a service contract that is derived from (and therefore may have formed dependencies upon) the underlying service logic, which makes the contract subject to change whenever the logic changes. The result is, predictably, a cascading effect whereby all service consumers are impacted (usually negatively) by the changes.

Service Façade can help avoid these situations by establishing an intermediary processing layer in between the core service logic and the service contract. The façade logic allows the service contract to remain decoupled from the underlying logic and further shields it from changes to the core business logic. This applies to both functional and behavioral changes, the latter of which may (often inadvertently) come about as a result of applying the Service Refactoring pattern. The façade layer can compensate for internal changes so that the service contract does not need to be modified as a result of the changes and/or the behavior of the functionality expressed in the contract is also not affected. In both cases, the service can evolve internally while existing service consumers remain protected from any potential side-effects.

6.4.4 Reference Architecture Profiling Enterprise Viewpoint

The Reference Architecture Profiling objective is to investigate ways to allow communities to tailor the existing OGC Reference Architecture into something that better suits their implementations and requirements. This would allow a standard architecture to be a framework, where the community could then pick and chose from these best practices to meet cost, schedule and development needs. This objective should provide the user informed options, outlining which items are required in order to have a OGC complaint architecture and which ones are optional or tailorable.

6.4.5 Bulk Data Transfer Enterprise Viewpoint

Bulk data transfer will focus on the transport of large quantities of data. The solution will use Streaming GML protocols (or GeoJSON), which is a solution that beings a convergence of the workstation hard wired into a network with a device that has limited thick client supplications and limited network connectivity. This exploration beings bridging the gap between a workstation and mobile solutions, utilizing standards and best practices, so a user can perform any task, with any data type, from any location without a major change in their workflow.

6.5 SSI Information Viewpoint

The Information Viewpoint describes the information models and encodings that will make up the content of the services and exchanges to be extended or developed to support the SSI thread activities in the following areas:

- Schema Automation Tool
- Geospatial data encoding
- Geospatial metadata encoding
- Efficient XML encoding
- File collection encoding
- Sensor Web Enablement (SWE) Common Data Model Encoding Standard
- Geospatial extensible Access Control Markup Language (GeoXACML)/XACML
- OASIS Web Services Notification
- Security Access Markup Language (SAML)
- SQLite
- Rasterlite

6.5.1 Schema Automation Tool

Relevant Specifications and Documents:

- *ShapeChange Tool* http://www.interactive-instruments.de/ugas
- *Object Constraint Language Specification, 2.0*
- *Schematron* http://www.schematron.com/
- *OGC 09-038r1 OWS-6 GML Profile Validation Tool ER*, 0.3.0,
- *OGC 08-078r1 OWS-5 GEOINT Schema Implementation Profile (GSIP) Schema Processing*, 0.0.3,

The UML to GML Application Schema (UGAS) tool which is called ShapeChange, was originally developed as part of the Geospatial One-Stop – Transport Pilot initiative (GOS-TP). It is used to facilitate creation of GML Application Schemas from information models expressed in UML. ShapeChange has been updated and enhanced during subsequent testbeds including OWS-2, OWS-3, OWS-4, and OWS-5. During OWS-7, ShapeChange was used to develop GML application schemas based on the latest version of GML (3.2.1).

ShapeChange Tool will be used as follows:

- Develop based on ISO 19139 encoding rules for metadata profiling (both restriction and extension).
- Implement the use of OCL/Schematron rules for specifying codelists.
- Enable support for OCL "let ... in" (and related) expressions, and optional support for XPath 2.0-based Schematron (second edition, draft).
- Improve the representation in KML from NAS data without generating GML as an intermediate step as well as the caching of data in KMZ files.
- Develop encoding rules in OCL to transform UML to GML, and other related encoding standards, for Observation and Measurement.

6.5.2 Geospatial data encoding

Relevant Specifications and Documents:

- *OpenGIS® Geography Markup Language (GML) Encoding Specification 3.2.1* http://portal.opengeospatial.org/files/?artifact_id=20509 (also published as ISO 19136)

The Geography Markup Language (GML) is an XML encoding for the transport and storage of geographic information, including both the geometry and properties of geographic features.

If XML is employed then GML shall be used as the geospatial data encoding format for bulk data transfer.

6.5.3 Geospatial metadata encoding

Relevant Specifications and Documents:

- *ISO 19115:2003 – Geographic information – Metadata*
- *ISO/TS 19139:2007 – Geographic Information – Metadata – XML Schema Implementation*
- *NSG Metadata Foundation (NMF) - Part 1 (v2.0.0),* https://www.gwg.nga.mil/protected/focus_groups/mfg/documents/NMF_%20v1.5.pdf
- *NSG Metadata Implementation Specification (NMIS) - Part 2 (v2.0.0),* https://www.gwg.nga.mil/protected/focus_groups/asfe/documents/NMIS_Part_2_v1.5.0_draft.pdf
- *North American Profile of ISO19115:2003 - Geographic information – Metadata (NAP – Metadata, version 1.2.1)*, http://www.fgdc.gov/standards/projects/incits-l1-standards-projects/NAP-Metadata

ISO 19115:2003 defines the schema required for describing geographic information and services. It provides information about the identification, the extent, the quality, the spatial and temporal schema, spatial reference, and distribution of digital geographic data. ISO 19115 defines an abstract model.

ISO/TS 19139:2007 takes the ISO 19115 abstract model and represents it as an XML schema. It provides an encoding schema for describing, validating, and exchanging metadata about geographic datasets, dataset series, individual geographic features, feature attributes, feature types, feature properties, etc. It is conformant with OGC GML 3.2.1.

The NSG Metadata Foundation (NMF) defines the conceptual schema profile for specifying geospatial metadata for use in the documentation, discovery and exchange of geospatial datasets in the U.S. National System for Geospatial Intelligence (NSG). It is an *ISO19106:2004 Geographic information – Profiles Class 2 profile of ISO 19115:2003/Cor 1:2006 Geographic information – Metadata* that includes extensions as required to meet U.S. DoD/IC metadata requirements. The companion NSG Metadata Implementation Specification (NMIS) defines the corresponding methods for specifying and encoding geospatial metadata in the NSG; it profiles and extends *ISO/TS19139:2007 Geographic information – Metadata – XML schema* implementation.

The *North American Profile of ISO19115:2003 Geographic information – Metadata (NAP)* is intended to identify geospatial metadata that are needed for North American organizations to describe their geospatial data, including dataset and dataset series, and related Web services. It is based on ISO19115:2003 and includes implementation perspectives from ISO/TS19139:2007.

All metadata should conform to ISO 19115 and, where applicable, ISO/TS 19139. All metadata should at a minimum fully support the NMF - Part 1 (v2.0.0) and, where applicable, the NMIS - Part 2 (v2.0.0). It is desirable that support be included for the content and XML-based encoding of the NAP where it differs from the NMF/NMIS.

6.5.4 File Collection Encoding

Relevant Specifications and Documents:

- *OWS-7 Information Sharing Engineering Report* (***includes OWS Context***), OGC document #10-035r2, http://portal.opengeospatial.org/files/?artifact_id=40441

That requirement also involves development of a "container" format for describing all the geospatial data files and their associated metadata in the bulk data file. This container may also contain metadata about itself, as well as efficiency and completeness mechanisms, such as indices into specific files or subsections of files, checksums on the bulk data file or specific files within the bulk data file, etc.

OWS Context is a container format originally designed for saving a set of geospatial data and services references. However, as it supports inclusion of data sets within the Context document, as well as relative referencing of data sets on a local file system, it may be appropriate for use in this thread.

6.5.5 Efficient XML Encoding

Relevant Specifications and Documents:

- *Efficient XML Interchange (EXI)* http://www.w3.org/TR/2008/WD-exi-20080919/
- *Binary Extensible Markup Language (BXML)* (Encoding Specification) OGC Discussion Paper 03-002r9, http://portal.opengeospatial.org/files/?artifact_id=13636
- *Sun Fast Infoset standard draft* http://java.sun.com/developer/technicalArticles/xml/fastinfoset/
- *W3C XML Information Set (second edition)* http://www.w3.org/TR/xml-infoset/
- *GZIP file format specification version 4.3, RFC 1952,* http://www.ietf.org/rfc/rfc1952.txt

The bulk data transfer container and file format requirements specify the need for attention to the efficiency and accuracy of data encoding. The data sets that may be distributed using this technology will often be quite large, and therefore it is critical to minimize file size, while still preserving the ability to read the data efficiently and make sure there is no loss of data in translation/export and transmission.

The W3C EXI specification provides a very compact representation for the Extensible Markup Language (XML) Information Set that is intended to simultaneously optimize performance and the utilization of computational resources. The EXI format uses a hybrid approach drawn from information and formal language theories, plus practical techniques verified by measurements, for entropy encoding XML information. Using a relatively simple algorithm, which is amenable to fast and compact implementation, and a small set of data types, it reliably produces efficient encodings of XML event streams.

The Binary XML specification specifies a binary encoding format for the efficient representation of XML data, especially scientific data that is characterized by arrays of numbers. The binary encoding method mirrors the typical in-memory representation of XML as nodes in a parse tree by representing the stream as a sequence of node-equivalent "tokens". It also recommends approaches for dealing with large numbers of coordinates in typical GML datasets.

The Fast Infoset standard draft (currently being developed as joint work by ISO/IEC JTC 1 and ITU-T) specifies a binary format for XML infosets that is an efficient alternative to XML. An instance of this binary format is called a fast infoset document. Fast infoset documents are analogous to XML documents. Each has a physical form and an XML infoset. Fast infoset documents have shown to be faster to serialize and parse, and smaller in size, than the equivalent XML documents. Thus, fast infoset documents may be used whenever the size and processing time of XML documents is an issue.

The binary format is optimized to balance the needs of both document size and processing time. Fast infoset documents are useful in a number of domains from bandwidth- and resource-constrained mobile devices to high-bandwidth high-throughput systems.

GZIP defines a lossless compressed data format that includes a cyclic redundancy check value for detecting data corruption. The format presently uses the DEFLATE method of compression but can be easily extended to use other compression methods. The format can be implemented readily in a manner not covered by patents.

6.5.6 Sensor Web Enablement (SWE) Common Data Model Encoding Standard

Relevant Specifications and Documents:

*SWE Common 2.0 Standard (*http://www.opengeospatial.org/standards/swecommon)
The Sensor Web Enablement (SWE) Common Data Model Encoding Standard defines low level data models for exchanging sensor related data between nodes of the OGC Sensor Web Enablement (SWE) framework. These models allow applications and/or servers to structure, encode and transmit sensor datasets in a self describing and semantically enabled way.

6.5.7 Geospatial extensible Access Control Markup Language (GeoXACML)/XACML

Relevant Specification and Documents:

- *XACML 2.0 – OASIS Standard* http://www.oasis-open.org/specs/#xacmlv2.0
- *GeoXACML OGC 07-026r2* - http://www.opengeospatial.org/standards/geoxacml
- *Geospatial Digital Rights Management Reference Model (GeoDRM RM) OGC 06-004r3* http://portal.opengeospatial.org/files/?artifact_id=14085
- *OWS-6 Security Engineering Report OGC 09-035* http://portal.opengeospatial.org/files/?artifact_id=35461

GeoXACML defines a geospatial extension to the OASIS XACML standard, incorporating spatial data types and spatial authorization decision functions based on the OGC Simple

Features and GML standards. Those data types and functions can be used to define additional spatial access constraints for XACML based policies. Essentially, GeoXACML supports the declaration and enforcement of access rights based on geographic information.

As a background, XACML together with associated schemas and resource profiles, defines the syntax and semantics for access control:

- Beside a schema to encode policies, XACML includes a request-response context schema that includes a specification of the generic data level interface between the Policy Enforcement Point (PEP) and the XACML processor/Policy Decision Point (PDP). Since GeoXACML only defines extensions to the policy-encoding schema, it doesn't affect the XACML request-response context schema and therefore doesn't include an interface specification of any kind.

XACML includes a model for an access control system. This incorporates stereotype definitions of a Policy Information Point (PIP), Policy Decision Point (PDP) or Authorization Service, Policy Administration Point (PAP) or License Manager, and a Policy Enforcement Point (PEP) or Gatekeeper, as well as their relations to each other in the context of an access control system. More information on how these components interact is available in the computational viewpoint.

6.5.8 OASIS Web Services Notification

Relevant Specifications:

- *OASIS WSN Base Notification 1.3*
  http://www.oasis-open.org/committees/download.php/20625/wsn-ws_base_notification-1.3-spec-os.pdf
- *OASIS WSN Brokered Notification 1.3*
  http://www.oasis-open.org/committees/download.php/20626/wsn-ws_brokered_notification-1.3-spec-os.pdf

The purpose of the OASIS Web Services Notification is to define a set of specifications that standardize the way Web services interact using "Notifications" or "Events". They form the foundation for Event Driven Architectures built using Web services. These specifications provide a standardized way for a Web service, or other entity, to disseminate information to a set of other Web services, without having to have prior knowledge of these other Web Services. They can be thought of as defining "Publish/Subscribe for Web services".

The WS-Notification family of specifications defines a standard Web services approach to notification. This document is the base specification on which all the other specifications in the family depend. It defines the normative Web services interfaces for two of the important roles in the notification pattern, namely the NotificationProducer and NotificationConsumer roles. This specification includes standard message exchanges to be implemented by service providers that wish to act in these roles, along with operational requirements expected of them.

6.5.9 Security Access Markup Language (SAML)

Relevant Specifications:

- *Security Assertion Markup Language (2.0)- OASIS Standard* http://saml.xml.org/saml-specifications

The Security Assertion Markup Language (SAML), developed by the Security Services Technical Committee of OASIS, is an XML-based framework for communicating user authentication, entitlement, and attribute information. As its name suggests, SAML allows business entities to make assertions regarding the identity and attributes of a subject (an entity that is often a human user) to other entities, such as a partner company or another enterprise application

6.5.10 SQLite

Relevant Specifications:

- *SQLite http://www.sqlite.org/about.html*
- *The TCl interface to the SQLite Library http://www.sqlite.org/tclsqlite.html*

SQLite is a in-process library that implements a self-contained, server less, zero-configuration, transactional SQL database engine. The code for SQLite is in the public domain and is thus free for use for any purpose, commercial or private. SQLite is currently found in more applications than we can count, including several high-profile projects.

SQLite is an embedded SQL database engine. Unlike most other SQL databases, SQLite does not have a separate server process. SQLite reads and writes directly to ordinary disk files. A complete SQL database with multiple tables, indices, triggers, and views, is contained in a single disk file. The database file format is cross-platform - you can freely copy a database between 32-bit and 64-bit systems or between big-endian and little-endian architectures. These features make SQLite a popular choice as an Application File Format. Think of SQLite not as a replacement for Oracle but as a replacement for fopen()

SQLite is a compact library. With all features enabled, the library size can be less than 350KiB, depending on the target platform and compiler optimization settings. (64-bit code is larger. And some compiler optimizations such as aggressive function inlining and loop unrolling can cause the object code to be much larger.) If optional features are omitted, the size of the SQLite library can be reduced below 200KiB. SQLite can also be made to run in minimal stack space (4KiB) and very little heap (100KiB), making SQLite a popular database engine choice on memory constrained gadgets such as cellphones, PDAs, and MP3 players. There is a tradeoff between memory usage and speed. SQLite generally runs faster the more memory you give it. Nevertheless, performance is usually quite good even in low-memory environments.

6.6 SSI Computational Viewpoint

The computational viewpoint is concerned with the functional decomposition of the FDF architecture into a set of services that interact at interfaces. It reflects the components, interfaces, interactions and constraints of the service architecture without regard to their distribution.

6.6.1 Security Management

Ensuring the security of Web services involves implementation of security frameworks based on use of authentication, authorization, confidentiality, and integrity mechanisms which include the following security techniques.

Confidentiality - Using XML Encryption as a mechanism to encrypt XML documents
Integrity - Using XML Signature to provide a means to selectively sign XML data
Authentication and Authorization - Using SAML and GeoXACML/XACML
Public Key Infrastructure (PKI) - using XKMS
WS-Security - SOAP header extensions for end-to-end SOAP messaging security which supports message integrity and confidentiality.
SAML v2.0 – security tokens.
WSDL, WS-Policy, WS-SecurityPolicy – Web service metadata

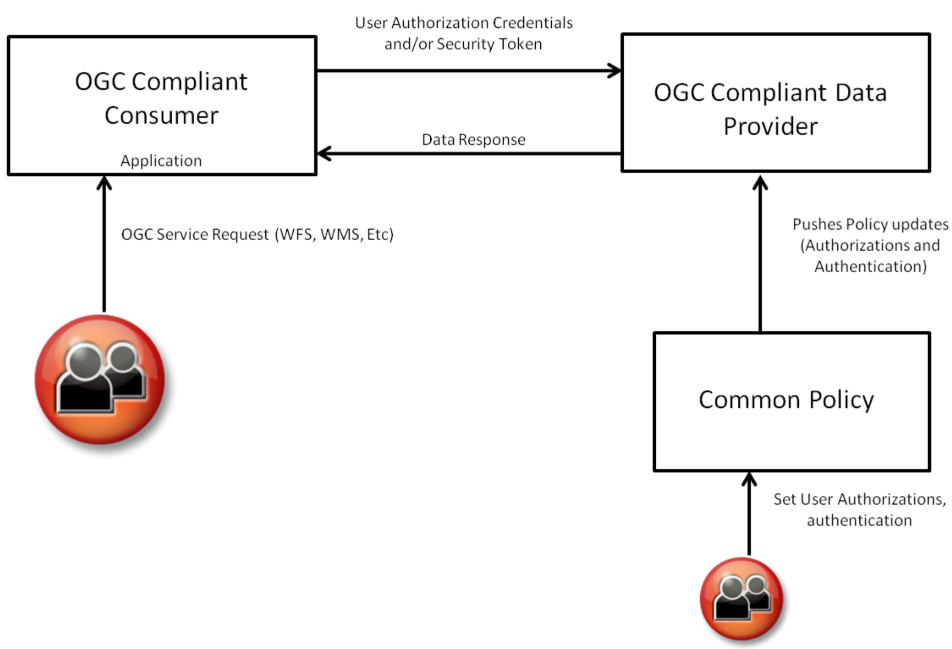

Figure 20 – Security Management Computational Viewpoint

The approach to security management is to provide one place in which all users within that community maintain each user's authentication and authorization information, referred to as the Common Policy. Whenever the common Policy is updated the user profiles will be pushed to all data providers registered to that policy. From there each OGC Compliant data service provider will then user the credentials or tokens received in each request, check it against the authorizations rules and only return data that user is permitted to see.

6.6.2 GML Application Schema UGA Updates

The UML to GML Application Schema (UGAS) tool which is called ShapeChange, was originally developed as part of the Geospatial One-Stop – Transport Pilot initiative (GOS-TP). It is used to facilitate creation of GML Application Schemas from information models expressed in UML. ShapeChange has been updated and enhanced during subsequent testbeds including OWS-2, OWS-3, OWS-4, OWS-5, and OWS-7. During OWS-9, The ShapeChange Tool advancement were as follows:

- Develop based on ISO 19139 encoding rules for metadata profiling (both restriction and extension).
- Implement the use of OCL/Schematron rules for specifying codelists.
- Enable support for OCL "let ... in" (and related) expressions, and optional support for XPath 2.0-based Schematron (second edition, draft).
- Improve the representation in KML from NAS data without generating GML as an intermediate step as well as the caching of data in KMZ files.
- Develop encoding rules in OCL to transform UML to GML, and other related encoding standards, for Observation and Measurement.
-

This objective in OWS-9 seeks develop and implement in the current open source ShapeChange tool integrated support for SWE Common 2.0 encoding rules alongside existing encoding rules for ISO 19136 and ISO/TS 19139.

6.6.3 Web Services Façade

The web service façade is a translation proxy, that will be able to translate requests from one OGC compliant format into another to allow services to request and receive data allowing 2 separate standard formats to communicate with each other. A HTTP Post request is made, but the data service provider only has a SOAP interface. The request goes into a proxy (the service façade) which translates the request into SOAP and sends the request on to the SOAP data provider. The data provider only communicates with the proxy and is unaware of the requesting consumer. The SOAP provider then generates a response, in it's native SOAP format and sends it back to the proxy. The Proxy then translates the data into a the format that the consumer requires, in this case HTTP Post.

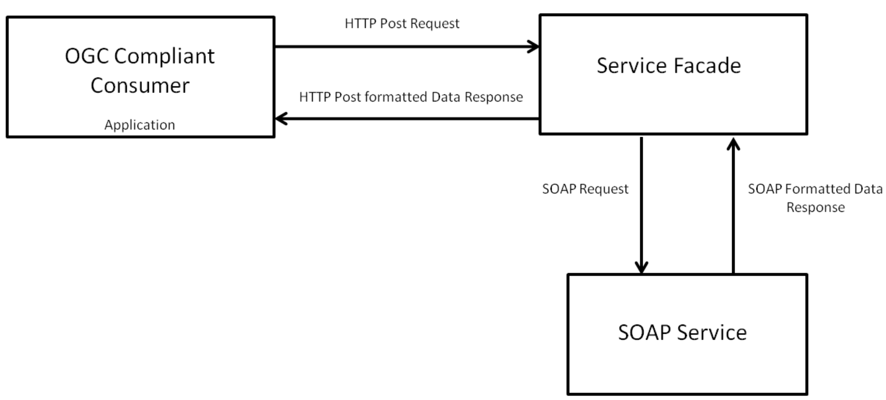

Figure 21 – Web Services Façade

6.6.4 Bulk Data Transfer

This objective will focus on the transfer of large quantities of imagery, raster and vector data. It will explore how to transport data using GML (or GeoJSON) streaming technologies. In addition the prototype will perform and use ISO and NMF metadata, checksum, and topology rules, to ensure data integrity and precision. Explore the usage of Spatialite and Rasterlite in caching of data. Ensuring a solution is compatible with mobile applications for future convergence of the workstation hard wired into a network with a device that has limited thick client supplications and limited network connectivity.

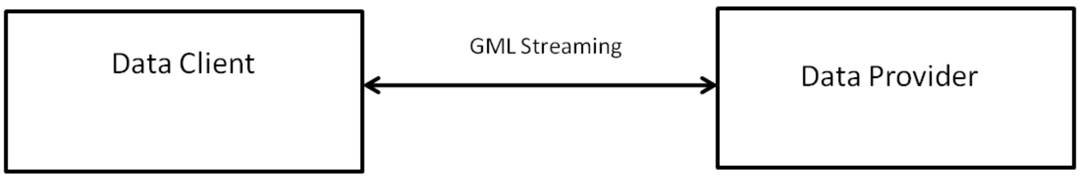

Figure 22 –Bulk data transfer

6.7 SSI Engineering Viewpoint

The Enterprise, Information, and Computation viewpoints describe a system in terms of its purposes, its content, and its functions. The Engineering viewpoint identifies component types in order to support distributed interaction between the components of the system. Those components interact based upon the services identified and described in the Computational viewpoint. Described below in the Engineering viewpoint for each objective is a basic notional scenario to understand how the components would interoperate in normal anticipated usage.

6.7.1 Security Management

Perform the Implementation of a Security Scenario:

1. User initiates a Query.
2. Token is passed (example SAML)
3. The data provider receives the token and uses it to check against the common policy to determine authorization
4. All authorized data within that satisfies the query request is passed.
5. When user profiles are added or updates and made to a user's authorizations, the updates are pushed to all data providers registered with the Common Policy.

6.7.2 Web Services Façade

Perform the Implementation of a Web Service Facade Scenario:

1. User submits a HTTP POST request
2. The service façade translates the request to SOAP
3. A SOAP Response is sent back to the web service façade
4. The Web service façade translates the response to HTTP POST
5. The user receives a valid response

6.7.3 Bulk Data Transfer

Perform the Implementation of a Bulk Data Transfer Scenario:

1. User requests download of data updates
2. The data is streamed to the user
3. The download gets interrupted.
4. The client knows how much of the download was received and when the connection resumes the download picks up where it left off
5. The data is visually displayed as it comes in.

7 OWS-9 Thread: OWS Innovations

7.1 OWS Innovations Thread Scope

As a thread of activity in OWS-9, OWS Innovations explore cutting edge topics, and those that require the most experimental, research-oriented approaches. The topics found in this thread represent either new areas of work for the Consortium (such as GPS and Mobile Applications), a desire for new approaches to existing technologies to solve new challenges (such as the WCS work), or some combination of the two.

This thread is segmented into four overarching topics: Geospatial Mobile Applications; Web Mapping; Coverage Access and Data Quality; and a GPS Study. Each of these objectives are described in greater detail below:

- **Geospatial Mobile Applications:** OGC seeks to further understand the requirements for developing standards-based geospatially-enabled mobile applications. Of particular interest is defining a best practice or standard for OGC web service mobile applications to consider such elements as certification and accreditation, security, quality of results, ease of operation, service descriptions, etc. Additional interest is in the area of defining an interoperable data structure for integrated feature, map and coverage data for handheld devices. The intent is to specify a simple structure to support data downloaded and cached onto a then disconnected mobile device that can collect data in a disconnected environment and synchronize the new data to master databases upon reconnection to the Internet.

- **Web Mapping:** Diverse competing and sometimes complementary raster data tiling schemes now exist in the marketplace, including WMTS, Tile Map Service (OSGeo), MBTiles, TileCache (MetaCarta), and various others. Participants shall evaluate these approaches and recommend alignment. We will also begin to look at ways to express data quality in OGC services and encodings, beginning with WMS, WMTS and KML.

- **Coverage Access and Data Quality:** A number of different data formats designed for specific-purpose use may be suitable for integration into an OGC Web Services environment. In this Testbed we look at NITF, LIDAR, and DAP/OPeNDAP, and investigate their re-implementation in an OWS environment with a focus on the Web Coverage Service 2.0 standard.

- **GPS Study:** Advances in GPS technology and new demands on the existing system have created the need for modernization efforts to implement the next generation of GPS. In this Testbed, participants will investigate the capabilities of OGC standards to support GPS data product and message requirements to include definition of a new one-size-fits-all Variable Message Format (VMF) message capable of supporting all potential GPS ephemeris/data.

7.2 OWS Innovations Thread Requirements

7.2.1 Geospatial Mobile Applications Requirements

References:

- HTML5: http://dev.w3.org/html5/spec/Overview.html
- Geolocation API: http://dev.w3.org/geo/api/spec-source.html
- OWS 7 Engineering Report -- Geosynchronization service (OGC 10-069) http://portal.opengeospatial.org/files/?artifact_id=39476
- OWS-8 Bulk Geodata Transfer Using GML Engineering Report (OGC 11-085) https://portal.opengeospatial.org/files/?artifact_id=46679
- *OWS-8 Bulk Geodata Transfer with File Geodatabase* (OGC 11-114) https://portal.opengeospatial.org/files/?artifact_id=45754
- FIPS 140-2: http://en.wikipedia.org/wiki/FIPS_140-2
- OpenSSL: http://www.openssl.org
- *see also SSI Thread Security Management References*

OGC seeks to further understand the requirements for developing standards-based geospatially-enabled mobile applications. Of particular interest is defining a best practice or standard for OGC web service mobile applications to consider such elements as certification and accreditation, security, quality of results, ease of operation, service descriptions, etc.

It is envisioned that the mobile app developed for OWS-9 will run on the Android operating system, may include data as part of the app download, may use the OWS Context format to initialize the map's state, and may be downloaded from an "app store".

Mobile Apps present a unique set of requirements when it comes to security. Participants shall evaluate different security methods which can be implemented at the service level and thus provide support for lightweight mobile applications ability to support authentication and authorization. Participants shall evaluate and prototype allowing for the passing of user identity within the service header/service description. This includes roles/groups as well as specific user ID (for limited distribution purposes) OR allow for the passing of user credentials, such an authenticated security token within the service fields. This requirement will likely include the ability to encrypt and unencrypt data on the mobile device. There is a preference for encryption to be implemented using OpenSSL libraries that have been accredited by FIPS 140-2.

Additional interest is in the area of defining an interoperable data structure for integrated feature, map and coverage data for handheld devices. The intent is to specify a simple structure to support data downloaded and cached onto a then disconnected mobile device. Participants shall develop a prototype mobile application to demonstrate the implementation of this simple common data structure across different data types; for example, vector, raster and 3D vector data. Participants shall develop a mobile app with the ability to collect field operations data in a disconnected environment and upload the newly collected data for automated synchronization to master databases upon reconnection to the Internet.

7.2.2 Web Mapping Requirements

References:

- OpenGIS® Web Map Tile Service Implementation Standard 1.0 (OGC 07-057r7): http://www.opengeospatial.org/standards/wmts
- Tile Map Service: http://wiki.osgeo.org/wiki/Tile_Map_Service_Specification
- MBTiles: http://mapbox.com/mbtiles-spec/

- TileCache: http://tilecache.org
- OpenGIS Web Map Service (WMS) Implementation Specification 1.3 (OGC 06-042): http://www.opengeospatial.org/standards/wms
- OpenGIS WMS Application Profile for EO Products (OGC 07-063r1): http://www.opengeospatial.org/standards/wms
- UncertML: http://www.uncertml.org
- Uncertainty Markup Language (UnCertML) 0.6 (OGC 08-122r2): http://portal.opengeospatial.org/files/?artifact_id=33234
- OGC KML 2.2 (07-147r2): http://www.opengeospatial.org/standards/kml
- ISO 19115
- ISO 19157

Diverse competing and sometimes complementary raster data tiling schemes now exist in the marketplace, including WMTS, Tile Map Service (OSGeo), MBTiles, TileCache (MetaCarta), and various others. Participants shall evaluate these approaches and recommend alignment.

7.2.3 Coverage Access Requirements

References:

- Web Coverage Service 2.0 suite of standards: http://www.ogcnetwork.net/wcs
- OpenGIS GML in JPEG 2000 for Geographic Imagery Encoding Specification 1.0 (OGC 05-047r3): http://www.opengeospatial.org/standards/gmljp2
- National Imagery Transmission Format (NITF): http://en.wikipedia.org/wiki/National_Imagery_Transmission_Format
- LIDAR: http://www.asprs.org/a/society/committees/lidar/
- LAS version 1.3 specification: http://www.asprs.org/society/committees/standards/lidar_exchange_format.html
- OPeNDAP: http://opendap.org
- The Data Access Protocol – DAP 2.0: http://www.esdswg.org/spg/rfc/ese-rfc-004
  The Data Access Protocol – DAP 2.0: https://portal.opengeospatial.org/files?artifact_id=47641
  (non-OGC members, email techdesk@opengeospatial.org for access to this document)
- ESIP GIS Cluster Presentation on OPeNDAP's WCS Service: http://opendap.org/node/271

A number of different data formats designed for specific-purpose use may be suitable for integration into an OGC Web Services environment. In this Testbed we look at NITF, LIDAR, and DAP/OPeNDAP, and investigate their re-implementation in an OWS environment with a focus on the Web Coverage Service 2.0 standard. We will also begin to look at ways to express data quality in OGC services and encodings, beginning with WMS, WMTS and KML.

In regards to Coverage Access with WCS and DAP/OPeNDAP, participants shall:

- Develop several use cases for access to coverage data, chosen to show range of variability of access needs
- Identify the strengths and weaknesses of WCS and OPeNDAP for access to coverage data in a web services environment.

- Develop a summary of analysis that provides a decision framework (Q&A driven) that results in recommendation when to use WCS vs. OPeNDAP.
- Provide recommendations for further development of coverage access services in OGC.

Regarding NITF, participants shall analyze the current NITF Standard to identify what areas are supported within the current GMLJP2 2.0 draft standard and what areas can be supported in the final release. Participants shall identify alternatives to incorporating support directly within GMLJP2 such as applicability of OWS Context to satisfy those missing capabilities.

Participants will also investigate the use of GMLJP2 as a wrapper for LIDAR data. Participants shall prototype LIDAR (LAS) data after processing to High Resolution Elevation (HRE) gridded format on a Web Coverage Service 2.0 implementation. The WCS implementation shall support the ability to deliver this data using the JPEG 2000 Interactive Protocol (JPIP) standard.

In this Testbed, we also look at data quality encoding. The proliferation of services providing KML and WMS data is making it difficult for users to select the ones that provide the data that has the right quality that fits their purpose. Currently, OGC standards do not specify how to distribute the quality of the data provided. There is a need for a common understanding on how to communicate quality metadata at the product, layer, and pixel level. Single overall quality indications can be expressed using ISO19115 metadata quality indicators (that will be superseded by the quality elements definition on 19157) and embedded directly in metadata documents linked to the service. The situation could be more complex when the quality information is provided with UncertML reach descriptions or the quality (that can be composed by more that one value) per pixel.

Considerations on how to best convey quality information to users employing widely used trust mechanisms and optimizing the design of the client systems for usability add some constrains and requirements to the problem. This activity has to be coordinated with efforts in associated provenance information for OGC services in the CCI and Provenance thread.

7.2.4 GPS Study Requirements

References:

- Variable Message Format: http://www.assistdocs.com/search/document_details.cfm?ident_number=215903

- Time-Space-Position Information: http://www.gwg.nga.mil/documents/TSPI_v1_0_1.doc

- OGC® SWE Common Data Model Encoding Standard 2.0 (08-094r1): http://www.opengeospatial.org/standards/swecommon

The Global Positioning System (GPS) is a space-based satellite navigation system that provides location and time information in all weather, anywhere on or near the Earth, where there is an unobstructed line of sight to four or more GPS satellites. Advances in GPS technology and new demands on the existing system have created the need for modernization efforts to implement the next generation of GPS. In this Testbed, participants will investigate the capabilities of OGC standards to support GPS data product and message requirements to include definition of a new one-size-fits-all Variable Message Format (VMF) message capable of supporting all potential GPS ephemeris/data.

One of the most significant error sources is the GPS receiver's clock. Because of the very large value of the speed of light, c, the estimated distances from the GPS receiver to the satellites, the pseudoranges, are very sensitive to errors in the GPS receiver clock; for example an error of one microsecond (0.000 001 second) corresponds to an error of 300 metres (980 ft). The U.S. Government continues to improve the GPS space and ground segments to increase performance and accuracy.

A GPS receiver calculates its position by precisely timing the signals sent by GPS satellites high above the Earth. Each satellite continually transmits messages that include:

- the time the message was transmitted
- precise orbital information (the **ephemeris**)
  - to provide more accurate satellite locations
  - providing each satellites own ephemeris data
- the general system health and rough orbits of all GPS satellites (the **almanac**)
  - providing predictive satellite locations

NGA provides 4 specialized functions related to the GPS. Each function contains its own computational model; these are *Filter*, *Short-Term Predictor*, *Smoother*, and *Long-Term Orbit Predictor*. Collectively these four functions produce GPS-related ephemeris and almanac data that are disseminated using bandwidth-constrained tactical networks.

The *Products Manager (processing)* function assembles data outputs from these functions and distributes them using the Product Distribution Service (PDS). Each function and its data outputs are described in **Appendix – GPS Support Function Descriptions (Section 9)**. In addition to the data outputs/packages described in **Section 9**, the DoD GPS community intends to collectively define additional new data products for disseminating information on:

- Earth orientation
- Orbit, clock, and Earth orientation covariance
- Composite or master clock and clock events
- Satellite attitude
- Satellite radiation pressure
- Satellite thrusts
- Station tropospheric refraction and weather data
- Station corrected and edited observations
- Station RMS residuals and number of observations

OGC seeks to understand the capabilities of OGC standards to support GPS data product and message requirements to include definition of a new one-size-fits-all Variable Message Format (VMF) message capable of supporting all potential GPS ephemeris/data. Consideration should be given to use and/or extension of the NGA GML-based Time-Space-Position Information standard in conjunction with SWE Common 2.0 types, as applicable. Participants should also be aware that this process is constrained by bandwidth limitations, and as such are encouraged to provide options or suggestions that are suitable to that environment.

7.3 OWS Innovations Thread Deliverables

The Deliverables are summarized in the Table with descriptions of the Deliverables in paragraphs following the table.

Table 4 – OWS Innovations Thread Deliverables Summary

1. OWS-9 OWS Innovations Mobile Apps Engineering Report
2. Mobile App Client - Secured Data Caching
3. Mobile App Client - Data Capture and Geosynchronization Client
4. OWS-9 OWS Innovations Map Tiling Methods Harmonization Engineering Report
5. OWS-9 OWS Innovations Data Quality for Web Mapping Engineering Report
6. WMTS Change Requests
7. WMTS Service (unfunded)
8. OWS-9 OWS Innovations GPS Study Engineering Report
9. OWS-9 OWS Innovations GMLJP2 for NITF Engineering Report
10. OWS-9 OWS Innovations WCS for LIDAR Engineering Report
11. GMLJP2-wrapped LIDAR HRE Data
12. WCS 2.0 Service - GML JP2, LIDAR HRE Gridded
13. WCS and GMLJP2 Change Requests
14. OWS-9 OWS Innovations Coverage Access Engineering Report
15. WCS 2.0 Change Requests – Coverage Access
16. WCS 2.0 Service - Coverage Access
17. OWS Context Document - GMLJP2, LIDAR, NITF capabilities

7.3.1 OWS-9 OWS Innovations Mobile Apps Engineering Report

Identify a standards-based set of requirements for mobile apps to include such elements as certification and accreditation, quality of results, ease of operation, service descriptions, etc.

7.3.2 Mobile App Client - Secured Data Caching

Prototype Mobile App demonstrating the ability to make use of pre-loaded data (cached and encrypted) on the device and used in a disconnected environment.

7.3.3 Mobile App Client - Data Capture and Geosynchronization

Prototype Mobile App for use in a disconnected environment supporting the ability to pre-load data, encrypt that data and then enable a field user to un-encrypt for further capture of additional data content such as terrain, feature, and/or building model data updates. Once connectivity is restored provide the ability to up-load the new data through a method supporting synchronization to multiple databases. OGC GSS is a consideration for implementing this geosynchronization.

7.3.4 OWS-9 OWS Innovations Map Tiling Methods Harmonization Engineering Report

Engineering Report capturing (1) the review of web map tiling schemes, including but not limited to WMTS, Tile Map Service (TMS), MBTiles, and UTFGrid, and (2) justifications for developing and specifying an update to WMTS and/or profiles of WMTS to improve leverage of the best features from these technologies.

7.3.5 OWS-9 OWS Innovations Data Quality for Web Mapping Engineering Report

Engineering Report that proposes the bases for WMS, WMTS and KML profiles for adding quality information at the product, layer, and pixel level.

This ER will be delivered to European Commission as a draft by July 2012 so a version of the ER is needed by the Preliminary Design and Implementations milestone (M4) in the OWS-9 Master Schedule. Development of the ER will continue in OWS-9 with a final version delivered to OGC by the Final Delivery milestone (M5) in the OWS-9 Master Schedule and subsequently to the EC.

7.3.6 WMTS Change Requests

If considered appropriate, propose updates to WMTS to harmonize with other tiling standards and methods.

7.3.7 WMTS Service (unfunded)

Implement a prototype WMTS service consistent with the data quality requirements expressed in deliverable OWSI-WMTS-1, and the change requests expressed in deliverable OWSI-WMTS-2.

7.3.8 OWS-9 OWS Innovations GPS Study Engineering Report

Analysis Study Engineering Report on the suitability of OGC Standards and services to support the requirements of the GPS community. Recommendations are sought on encodings, formats, web service architecture, process streamlining and ease integration of results into the user segment.

7.3.9 OWS-9 OWS Innovations GMLJP2 for NITF Engineering Report

Analysis Engineering Report (study) of current NITF capabilities identifying what is supportable by GMLJP2 2.0 (draft) with recommendations on how to achieve full support, using GMLJP2 independent of other OGC standards or in conjunction with other OGC standards, of the varieties of imagery and gridded datasets listed in the NITF section of the Information Viewpoint. Documentation of the results of this Testbed developed encoding effort.

7.3.10 OWS-9 OWS Innovations WCS for LIDAR Engineering Report

Engineering Report documenting WCS 2.0 support for delivery of LIDAR derived HRE data.

7.3.11 GMLJP2-wrapped LIDAR HRE Data

GMLJP2-wrapped LIDAR derived High Resolution Elevation gridded data.

7.3.12 WCS 2.0 Service - GML JP2, LIDAR Gridded

WCS 2.0 JPIP enabled prototyped support for GMLJP2, LIDAR gridded.

7.3.13 WCS and GMLJP2 Change Requests

Change Requests for WCS 2.0 and GMLJP2.

7.3.14 OWS-9 OWS Innovations Coverage Access Study Engineering Report

Engineering Report documenting results of analysis of accessing a variety of coverage data types considering WCS 2.0 and DAP 2.0 interfaces.

7.3.15 Coverage Access Innovations Study: WCS 2.0 Change Requests

Change Requests for WCS 2.0 with regards to Coverage Access Study.

7.3.16 WCS 2.0 Service – Access Innovations

Implementation of concepts developed in the WCS Coverage Access Innovations study.

7.3.17 OWS Context Document - GMLJP2, LIDAR, NITF capabilities

Prototype OWS Context document with in-line support for NITF capabilities not covered in GMLJP2 and a GMLJP2 NITF LIDAR derived data set.

7.4 OWS Innovations Enterprise Viewpoint

7.4.1 Geospatial Mobile Applications Enterprise Viewpoint

The Mobile Internet refers to Internet-connected applications, often browser-based, that run on mobile devices such as smartphones, tablet computers or embedded computers (in cars or tanks, for example) that have wireless access to the Internet. Most such devices can determine their position (through GPS or other means) and report their position to applications that deliver location services such as wayfinding. The OGC works to make mobile device location information more usable and useful in applications that "mashup" user location or sensor location with the locations of road hazards, property lines, charging stations, flood zones, products, hospitals, hiking trails and almost anything else on Earth.

Mobile applications have special concerns for the geospatial marketplace. Geospatial applications, due to their large data volumes and often high-computational needs, have traditionally resided on industrial-strength computers. So optimization for lower end processors and environments where bandwidth and battery life are highly constrained has not been a pressing priority. This market segment presents a new challenge for OGC members, not only from a technology perspective, as described above, but also from a management standpoint. How are mobile applications deployed? Does data distribution change from the traditional paradigm to one in which data comes with the application, as is common in mass market mobile apps? Must data formats be simplified to get high performance without sacrificing battery life? How do security requirements change with a device that can be passed from person to person so easily? Since mobile apps often update themselves, how can one be sure that no malicious code (or bad data) has been included in an update? Conversely, how can automatic updating solve data quality, provenance, and synchronization challenges we have today?

There are more questions than answers at this point in the evolution of the geospatial mobile applications market, so this topic is highly experimental. At this early stage, of particular interest is defining a best practice or standard for OGC web service mobile applications to consider such elements as certification and accreditation, security, quality of results, ease of operation, service descriptions, etc.

Additional interest is in the area of defining an interoperable data structure for integrated feature, map and coverage data for handheld devices. The intent is to specify a simple structure to support data downloaded and cached onto a then disconnected mobile device that can collect data in a disconnected environment and synchronize the new data to master databases upon reconnection to the Internet.

7.4.2 Web Mapping Enterprise Viewpoint

The original motivation for the WMTS standard was to improve web mapping performance by making map requests fit better within the standard Web architecture, thereby taking advantage of performance methods available to all HTTP request-response interactions. For example, a single WMS request may be replaced by 16 WMTS requests to generate the same map, but the image returned by that single WMS request must be discarded upon each map pan or zoom event. The map tiles returned by a WMTS request can easily be re-used on the client side. Furthermore, since there are a finite number of possible WMTS requests for a specific layer, all the responses can be cached by the server (and possibly by intermediate equipment such as routers and proxies), requiring no computation to service map requests.

This approach to web mapping has been very popular, and has generated a host of diverse, competing and sometimes complementary raster data tiling schemes in the marketplace. Reducing this diversity through harmonization of standards will benefit the industry by simplifying software development efforts by web map tiling implementers. Therefore OGC sees web map tiling standards harmonization as a great benefit to the market.

The proliferation of services providing data via visualization services and encodings such as KML, WMS and WMTS is further obscuring the fitness-for-use of the original data sources. None of these standards currently provide any recommendation as to how to distribute the quality of the data viewed.

There are some obvious solutions for WMS and WMTS that can be used, such as leveraging the MetadataURL link. But there is a need for a more generic understanding of how to communicate quality metadata at the product, layer, and pixel level. Single overall quality indications can be expressed using ISO19115 metadata quality indicators (that will be superseded by the quality elements definition on 19157) and embedded directly in metadata documents linked to the service. The situation could be more complex when the quality information is provided in the form of UncertML reach descriptions or the quality (that can be composed by more that one value) per pixel. Uncertainties can by expressed as new layers that can be seen or queried. In fact, GetFeatureInfo operation can be combined with UncertML to retrieve data values and their uncertainties in a numerical or graphical form.

Considerations on how to best convey quality information to users employing widely used trust mechanisms and optimizing the design of the client systems for usability add some constraints and requirements to the problem.

7.4.3 Coverage Access and Data Quality Enterprise Viewpoint

Continuing to unify Coverage data access via the WCS interface benefits the marketplace by allowing for software re-use and a familiar interface for not only delivering the data itself, but also for communicating metadata related to quality, fitness-for-use, provenance, and more. A common interface also opens greater possibilities for distributed visualization and computational processing employing diverse data formats. Therefore, this thread continues the pursuit of this goal by exploring the use of WCS and GMLJP2 and OWS Context for accessing NITF, LIDAR and data traditionally access through DAP/OPeNDAP.

7.4.4 GPS Study Enterprise Viewpoint

The Global Positioning System (GPS) is a space-based satellite navigation system that provides location and time information in all weather, anywhere on or near the Earth, where there is an unobstructed line of sight to four or more GPS satellites. It is maintained by the United States government and is freely accessible by anyone with a GPS receiver. The system imposes some technical limitations which are only removed for authorized users.

The GPS program provides critical capabilities to military, civil and commercial users around the world. In addition, GPS is the backbone for modernizing the global air traffic system.

The GPS project was developed in 1973 to overcome the limitations of previous navigation systems, integrating ideas from several predecessors, including a number of classified engineering design studies from the 1960s. GPS was created and realized by the U.S. Department of Defense (DoD) and was originally run with 24 satellites. It became fully operational in 1994.

Advances in technology and new demands on the existing system have now led to efforts to modernize the GPS system and implement the next generation of GPS III satellites and Next Generation Operational Control System (OCX). Announcements from the Vice President and the White House in 1998 initiated these changes. In 2000, U.S. Congress authorized the modernization effort, referred to as GPS III.

A GPS receiver calculates its position by precisely timing the signals sent by GPS satellites high above the Earth. Each satellite continually transmits messages that include

- the time the message was transmitted
- precise orbital information (the ephemeris)
- the general system health and rough orbits of all GPS satellites (the almanac)

The receiver uses the messages it receives to determine the transit time of each message and computes the distance to each satellite. These distances along with the satellites' locations are used with the possible aid of trilateration, depending on which algorithm is used, to compute the position of the receiver.

One of the most significant error sources is the GPS receiver's clock. Because of the very large value of the speed of light, the estimated distances from the GPS receiver to the satellites, the pseudo-ranges, are very sensitive to errors in the GPS receiver clock; for example an error of one microsecond (0.000 001 second) corresponds to an error of 300 meters (980 feet). Correcting for errors through post-processing of GPS data is critical to locational accuracy. Post-processing requires comprehensive metadata regarding all aspects of the GPS measurement, and is the motivation for this study.

7.5 OWS Innovations Information Viewpoint

The information viewpoint is concerned with the semantics of information and information processing. Presented here are various information modeling and encoding standards that have direct relevance to the requirements of the thread.

7.5.1 Coverage Concept

Reference: "The OGC Abstract Specification Topic 6: Schema for coverage geometry and functions," OGC document 07-011, also published as ISO 19123

Coverages represent digital geospatial information representing space/time-varying phenomena. OGC Abstract Topic 6 defines an abstract model of coverages. Coverage is a feature that associates positions within a bounded space (its domain) to feature attribute values (its range). In other words, it is both a feature and a function. Examples include a raster image, a polygon overlay or a digital elevation matrix.

7.5.2 GML Application Schema - Coverages

Reference: OGC GML Application Schema – Coverages, OGC Document 09-146r1

Coverage instances may be encoded using the Geography Markup Language (GML) 3.2 [07-036], an XML grammar written in XML Schema for the description of application schemas as well as the transport and storage of geographic information.

However, the definition contained in GML 3.2.1 has turned out to not contain sufficient information to describe coverage instances in a flexible, interoperable, and harmonized manner. To remedy this, document 09-146 defines a GML Application Schema for Coverages and defines several enhancements to the GML 3.2.1 Coverage data type. The document defines a strict extension: no existing part of the GML 3.2.1 [OGC 07-036] Coverage is changed in its syntax, nor in its semantics.

7.5.3 LIDAR

Reference: LAS version 1.3 specification:
http://www.asprs.org/society/committees/standards/lidar_exchange_format.html

LIDAR (Light Detection And Ranging, also LADAR) is an optical remote sensing technology that can measure the distance to, or other properties of a target by illuminating the target with light, often using pulses from a laser. LIDAR uses ultraviolet, visible, or near infrared light to image objects and can be used with a wide range of targets, including non-metallic objects, rocks, rain, chemical compounds, aerosols, clouds and even single molecules. A narrow laser beam can be used to map physical features with very high resolution.

LIDAR has been used extensively for atmospheric research and meteorology. Downward-looking LIDAR instruments fitted to aircraft and satellites are used for surveying and mapping – a recent example being the NASA Experimental Advanced Research LIDAR.

7.5.4 NITF

Reference: National Imagery Transmission Format Version 2.1: http://www.gwg.nga.mil/ntb/baseline/docs/2500c/index.html

The National Imagery Transmission Format Standard (NITFS) is a U.S. Department of Defense (DoD) and Federal Intelligence Community (IC) suite of standards for the exchange, storage, and transmission of digital-imagery products and image-related products.

Participants shall ascertain the degree to which GMLJP2 can provide the functional equivalent, or better, description of the information content of the varieties of imagery and gridded datasets listed. The specifications listed below are openly available without fee.

A. Traditional mapping, charting and geodesy (MC&G) NITF-formatted product lines.
    a. MIL-PRF-89041A, Controlled Image Base (CIB)
    b. MIL-PRF-89038, Compressed Arc Digitized Raster Graphics (CADRG)
    c. MIL-PRF-32283, Enhanced Compressed Raster Graphics (ECRG)
    d. MIL-PRF-*****, Enhanced Controlled Image Base (ECIB) (not yet published, but very similar to ECRG)
    e. MIL-PRF-89034(1), Digital Point Position Database (DPPBD)
    f. MIL-PRF-89020B(1), Digital Terrain Elevation Data (DTED)
    g. NGA.IP.0002_1.0, Implementation Profile for High Resolution Elevation (HRE) Products (2009-10-23), Version 1.0
B. Commercial satellite products described in *STDI-0006, National Imagery Transmission Format (NITF) Version 2.1 Commercial Dataset Requirements Document (NCDRD)*, 18 February 2010.
    a. Processing Level P: Pre-Processed (also known as Radiometrically-Corrected) - Basic level of image processing to provide radiometric and sensor corrections.
        i. P1 Panchromatic
        ii. P2 Multispectral
        iii. P3 Pan-Sharpened
    b. Processing Level G: Geo-Referenced (also known as Geo-Rectified) - Pre-Processed level of processing plus additional image processing to provide geometric corrections and mapping to a cartographic projection.
        i. G1 Panchromatic
        ii. G2 Multispectral
        iii. G3 Pan-Sharpened
    c. Processing Level R: Ortho-Rectified - Geo-Referenced level of processing plus additional image processing to remove terrain relief displacement with ground control points and/or digital elevation models.
        i. G1 Panchromatic
        ii. G2 Multispectral
        iii. G3 Pan-Sharpened

C. Tactical Intelligence, Surveillance and Reconnaissance (ISR) system (non-rectified imagery) that has sensor parameters based on the Community Sensor Model (CSM) to support ground-to-image positioning, adjustability, and error propagation. See NITF TRE SENSRB for traditional TRE approach to representation of the 'conceptual' CSM.
    a. EO/IR/Spectral
    b. Frame / Pushbroom / Whiskbroom
    c. Frame grab from motion imagery stream
    d. Series of select frame grabs from motion imagery stream
    e. Stereo / Multi-Look

D. Emerging Sensor Independent Complex Image Data (SICD) specification and the associated Sensor Independent Derived Data (SIDD) specifications for Synthetic Aperture Radar (SAR) sources.

E. Various 'compositions' of imagery and gridded data content within a single product/file. A few representative types of composition are:
    a. Image with graphical annotations/overlay and textual/HTML/XML analysis report
    b. Image with scanned map, elevation data and cloud cover (raster, vector, and both)
    c. Multiple images, each with different ground sample distance, and associated graphical annotations
    d. Image/scanned map with ground moving target indicator report
    e. Spectral image (4 or more bands) with selected bands identified for initial portrayal
    f. Spectral image (4 or more bands) with per-pixel-per-band quality attribute mask

7.5.5 VMF

Reference: Variable Message Format (VMF):
http://www.assistdocs.com/search/document_details.cfm?ident_number=215903

The Variable Message Format (VMF) Military Standard provides military services and agencies with Joint interoperability standards, including message, data element, and protocol standards. VMF is the current encoding format for GPS ephemeris (metadata).

7.5.6 JPEG 2000

Reference: JPEG 2000: http://www.jpeg.org/jpeg2000/

JPEG 2000 is an image coding system that uses compression techniques based on wavelet technology. It provides the ability to include XML data for description of the image within the JPEG 2000 data file.

7.5.7 GML in JPEG 2000 for Geographic Imagery Encoding (GMLJP2)

Reference: GML in JPEG 2000 for Geographic Imagery Encoding:
http://www.opengeospatial.org/standards/gmljp2

GMLJP2 defines the means by which GML is used within JPEG 2000 images for geographic imagery. The standard also provides packaging mechanisms for including GML within JPEG 2000 data files and specific GML application schemas to support the encoding of images within JPEG 2000 data files.

7.5.8 Geography Markup Language (GML)

Reference: http://www.opengeospatial.org/standards/gml

GML is an XML grammar for expressing geographical features. GML serves as a modeling language for geographic systems as well as an open interchange format for geographic transactions on the Internet.

7.5.9 KML

Reference: OGC KML: http://www.opengeospatial.org/standards/kml

KML is an XML language focused on geographic visualization, including annotation of maps and images. Geographic visualization includes not only the presentation of graphical data on the globe, but also the control of the user's navigation in the sense of where to go and where to look. From this perspective, KML is complementary to most of the key existing OGC standards including GML (Geography Markup Language), WFS (Web Feature Service) and WMS (Web Map Service). Currently, KML 2.2 utilizes certain geometry elements derived from GML 2.1.2. These elements include point, line string, linear ring, and polygon.

7.5.10 netCDF

Reference: GML in JPEG 2000 for Geographic Imagery Encoding: http://www.opengeospatial.org/standards/gmljp2

GMLJP2 defines the means by which GML is used within JPEG 2000 images for geographic imagery. The standard also provides packaging mechanisms for including GML within JPEG 2000 data files and specific GML application schemas to support the encoding of images within JPEG 2000 data files.

7.5.11 Hierarchical Data Format (HDF)

Reference: Hierarchical Data Format: http://en.wikipedia.org/wiki/Hierarchical_Data_Format

Hierarchical Data Format (HDF, HDF4, or HDF5) is the name of a set of file formats and libraries designed to store and organize large amounts of numerical data. HDF is self-describing, allowing an application to interpret the structure and contents of a file with no outside information. One HDF file can hold a mix of related objects which can be accessed as a group or as individual objects. HDF data has been served via WCS in OWS-9.

7.5.12 SWE Common Data Model Encoding

Reference: http://www.opengeospatial.org/standards/swecommon

SWE Common defines low-level data models for exchanging sensor related data between nodes of the OGC® Sensor Web Enablement (SWE) framework. These models allow applications and/or servers to structure, encode and transmit sensor datasets in a self-describing and semantically enabled way.

As GPS data is an observation from a sensor (a GPS satellite), this standard should be considered as a method for managing information in the GPS study.

7.5.13 OWS Context

Reference: https://portal.opengeospatial.org/twiki/bin/view/OWSContextswg/WebHome (OGC members only link)

Web Map Context (WMC) is an existing OGC Standard that allows a user to capture the state of a map composed of many WMS services in an XML format. Service bindings, scale, legend graphics, and all other state elements related to the WMS interface can be saved in a WMC document. OWS Context (OWC) extends this concept to cover all OGC services and information encodings. OWC documents will be able to package service requests to, e.g., WMS, WFS, WCS and SOS, and also handle file formats such as KML and GML. It also allows for inline data to be stored in the document.

One point of relevance to this thread is that OWC may be an excellent alternative to NITF when integration with OGC Web Services is desirable.

7.5.14 UncertML

Reference: UncertML: http://www.uncertml.org/

UncertML is a conceptual model and XML encoding designed for encapsulating probabilistic uncertainties.

UncertML has a central role to play in helping describe data quality in OGC services and information encodings.

7.5.15 HTML5

Reference: http://dev.w3.org/html5/spec/Overview.html

The World Wide Web's markup language has always been HTML. HTML was primarily designed as a language for semantically describing scientific documents, although its general design and adaptations over the years have enabled it to be used to describe a number of other types of documents.

The main area that has not been adequately addressed by HTML is a vague subject referred to as Web Applications. This specification attempts to rectify this, while at the same time updating the HTML specifications to address issues raised in the past few years.

7.6 OWS Innovations Computational Viewpoint

The computational viewpoint is concerned with the functional decomposition of the system into a set of services that interact at interfaces.

7.6.1 Geosynchronization Service (GSS)

Reference: OWS 7 Engineering Report -- Geosynchronization service (OGC 10-069r2): http://portal.opengeospatial.org/files/?artifact_id=39476

A Geosynchronization service, deployed by a data provider, sits between the provider's data store(s) and data collectors. It allows data collectors to submit new data or make modifications to existing data without directly affecting the data in the provider's data store(s) until validation has been applied thus ensuring that the data published by the provider is of high quality.

7.6.2 Sensor Observation Service (SOS)

Reference: OpenGIS Sensor Observation Service 1.0.0, OGC Document 06-009r6 , http://www.opengeospatial.org/standards/sos

SOS may be relevant to the storage and transmission of GPS metadata.

An SOS organizes collections of related sensor system observations into Observation Offerings. The concept of an Observation Offering is equivalent to that of a sensor constellation. An Observation Offering is also analogous to a “layer” in Web Map Service because each offering is intended to be a non-overlapping group of related observations.

7.6.3 Web Coverage Service (WCS) Version 2.0

Reference: WCS 2.0 Suite of Interface Standards: http://www.opengeospatial.org/standards/wcs

A number of data types in this thread expect to use the WCS interface as a data access mechanism.

The OGC Web Coverage Service (WCS) supports electronic retrieval of geospatial data as "coverages" – that is, digital geospatial information representing space/time-varying phenomena.

WCS 2.0 consists of a set of normative specifications, collectively referred to as “the WCS suite”. These specifications encompass:

- GML 3.2 Application Schema for WCS [OGC 09-146]
- WCS 2.0 Core [OGC 09-110]
- A set of extensions to the WCS Core.

Document 09-153 provides an overview on the OGC Web Coverage Service (WCS) 2.0 suite by describing WCS core and extensions. As such, the contents of this document is informative and not of normative nature.

WCS Core and each extension specify, as normative requirements, which prerequisite specifications they require. Frequently, options are possible in some specific group of extensions; for example, every WCS implementation must support at least one protocol extension.

This constitutes a dependency graph as shown in Figure 23.

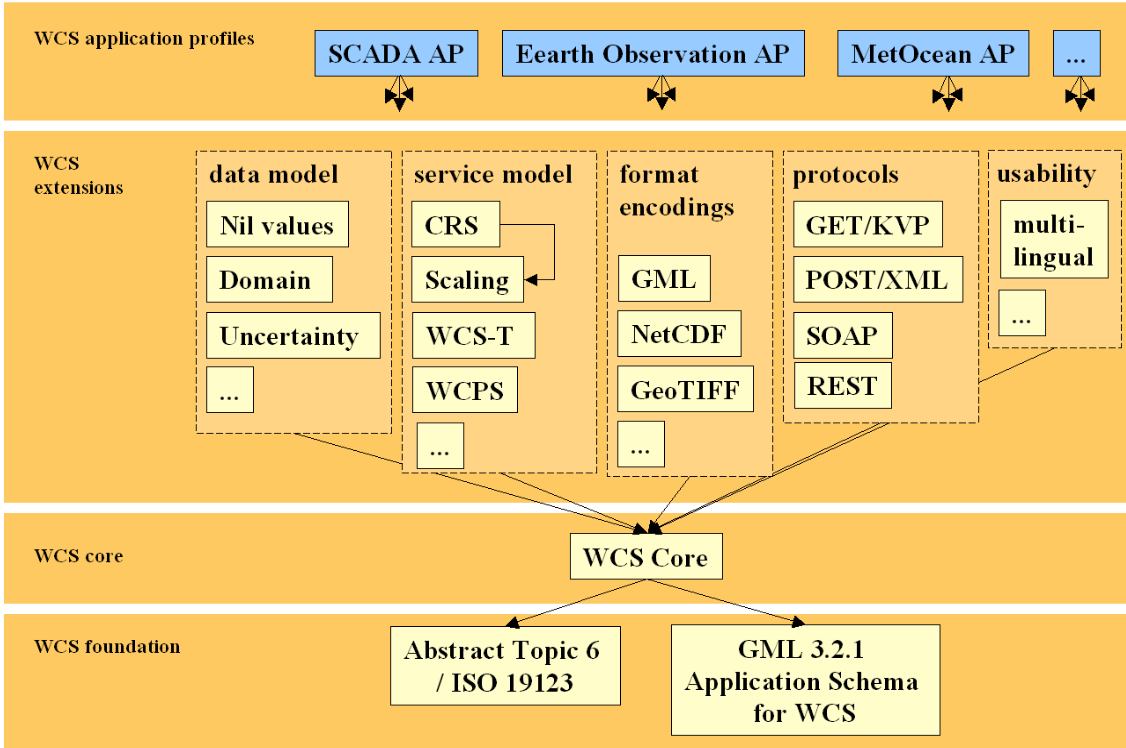

Figure 23 WCS specification hierarchy graphical overview

7.6.4 WCS 2.0 Application Profile – Earth Observations

Reference: OWS-8 WCS 2.0 Earth Observation Application Profile Engineering Report, OGC Document 11-095

This engineering report specifies one approach to providing a service interface on complex earth science data. As such, it will provide excellent guidance on this thread's approach to serving data via WCS.

This WCS Application Profile for Earth Observation is an OGC Interface Standard which relies on WCS 2.0 (the Core [OGC 09-110r3] plus selected extensions), the GML Application Schema for Coverages [OGC 09-146r1], the GML Earth Observation Application Schema [OGC TBD], and GML 3.2.1 [TBD].

The OGC Web Coverage Service (WCS) Application Profile – Earth Observation, in short: EO-AP, specializes the generic WCS 2.0 [OGC 09-110r3] for use on earth observation data. An Application Profile bundles several specifications and possibly adds additional requirements on an implementation.

7.6.5 WCS Support for JPEG 2000 and JPIP Coverage Subsetting

Reference: OWS-5 WCS JPIP Coverage Subsetting Engineering Report 0.9.0 (OGC 07-169): http://portal.opengeospatial.org/files/?artifact_id=27047

Reference: OWS-4 IPR for WCS Support for JPEG 2000 (OGC 06-128): https://portal.opengeospatial.org/files/?artifact_id=20258

These OGC documents represent Testbed work on sub-setting georeferencable imagery. They discuss how to handle georeferencable imagery in the JPEG2000 format as well as using JPIP within the WCS-T and the SWE set of services.

7.6.6 Web Map Service (WMS)

Reference: WMS Implementation Specification 1.3: http://www.opengeospatial.org/standards/wms

WMS provides a simple HTTP interface for requesting geo-registered map images from one or more distributed geospatial databases. A WMS request defines the geographic layer(s) and area of interest to be processed. The response to the request is one or more map images (returned as JPEG, PNG, etc.) that can be displayed in a browser application.

7.6.7 Web Map Tiling Service (WMTS)

Reference: OpenGIS Web Map Tile Service Implementation Standard: http://www.opengeospatial.org/standards/wmts

WMTS offers a complementary approach to WMS by tiling maps. WMS focuses on rendering custom maps and is an ideal solution for dynamic data or custom styled maps. WMTS focuses on fast serving of static data constraining the bounding box and scales to discrete tiles. WMTS makes it easier to leverage Web technologies for scalability like caching, pre-rendering and clustering.

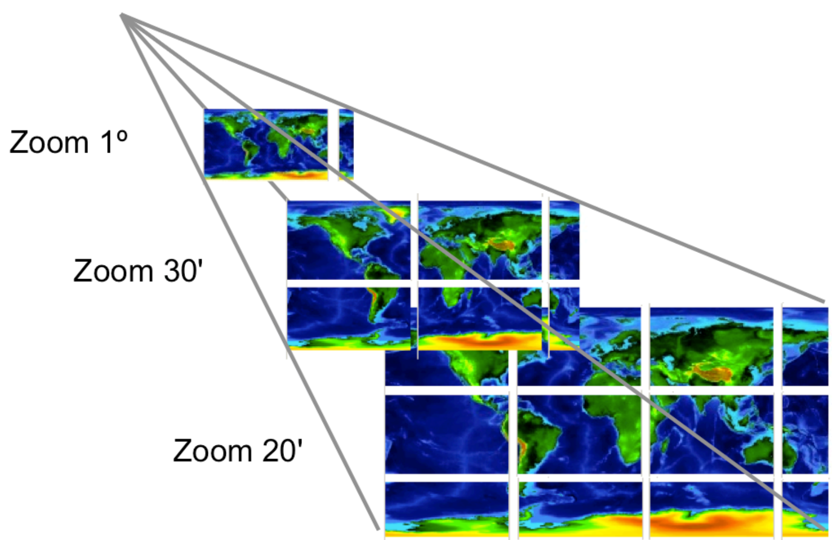

Figure 24 – WMTS Tile Matrix Set

7.6.8 SQLite

Reference: http://www.sqlite.org/about.html

The geospatial mobile applications work in this thread requires implementing a simple, single file format solution for all kinds of geographic data, including raster, vector, three-dimension data, etc. SQLite and associated geographic extensions – SpatiaLite and librasterlite are initially seen to be the most promising path to satisfy this requirement.

SQLite is an embedded SQL database engine. Unlike most other SQL databases, SQLite does not have a separate server process. SQLite reads and writes directly to ordinary disk files. A complete SQL database with multiple tables, indices, triggers, and views, is contained in a single disk file. The database file format is cross-platform - you can freely copy a database between 32-bit and 64-bit systems or between big endian and little endian architectures. These features make SQLite a popular choice as an Application File Format. Think of SQLite not as a replacement for Oracle but as a replacement for fopen().

7.6.9 SpatiaLite

Reference: https://www.gaia-gis.it/fossil/libspatialite/index

SpatiaLite is an open source library intended to extend the SQLite core to support full-fledged Spatial SQL capabilities. SpatiaLite is smoothly integrated into SQLite to provide a "mostly OGC-SFS compliant" Spatial DBMS.

7.6.10 librasterlite

Reference: https://www.gaia-gis.it/fossil/librasterlite/index

Librasterlite is an open source library allowing storage of large raster Coverages within a SpatiaLite DBMS.

7.6.11 Geolocation API

Reference: http://dev.w3.org/geo/api/spec-source.html

The Geolocation API defines a high-level interface to location information associated only with the device hosting the implementation, such as latitude and longitude. The API itself is agnostic of the underlying location information sources. Common sources of location information include Global Positioning System (GPS) and location inferred from network signals such as IP address, RFID, WiFi and Bluetooth MAC addresses, and GSM/CDMA cell IDs, as well as user input. No guarantee is given that the API returns the device's actual location.

The API is designed to enable both "one-shot" position requests and repeated position updates, as well as the ability to explicitly query the cached positions. Location information is represented by latitude and longitude coordinates.

7.7 OWS Innovations Engineering Viewpoint

The engineering viewpoint defines a set of components that provide the basis for deployment in a distributed environment. Initial consideration for identification of Engineering is to consider the components identified in the Enterprise viewpoint. Engineering components are accessed through services. Engineering Components handle data. The services and data that are used to define engineering components are defined in the previous viewpoints.

7.7.1 Geospatial Mobile Applications Engineering Viewpoint

The geospatial mobile applications work covers requirements in four broad use cases. First is the application access use case, in which the mobile client finds an application by querying and/or browsing an application catalog, or "store". The application may or may not come with embedded data. But a strict requirement of the thread is that the communications channel between client and service is secured.

The second use case is concerned with the bulk download for low and no bandwidth use of geospatial data to the mobile client into a single, simple data package that supports as many types of geospatial data as possible, such as two and three-dimensional vector and raster grid data types. Initial research indicates that a SQLite/Spatialite/librasterlite software stack implementation is most likely the best strategy to fulfill this requirement.

In use case three, the mobile application performs field data updates and uses the downloaded data to do geospatial analyses such as computing line-of-site view sheds.

Finally, in the fourth use case, the mobile application comes home, or connects to the Internet, and the field updates are uploaded to the server via Geosynchronization. OGC GSS is a consideration for implementing this geosynchronization.

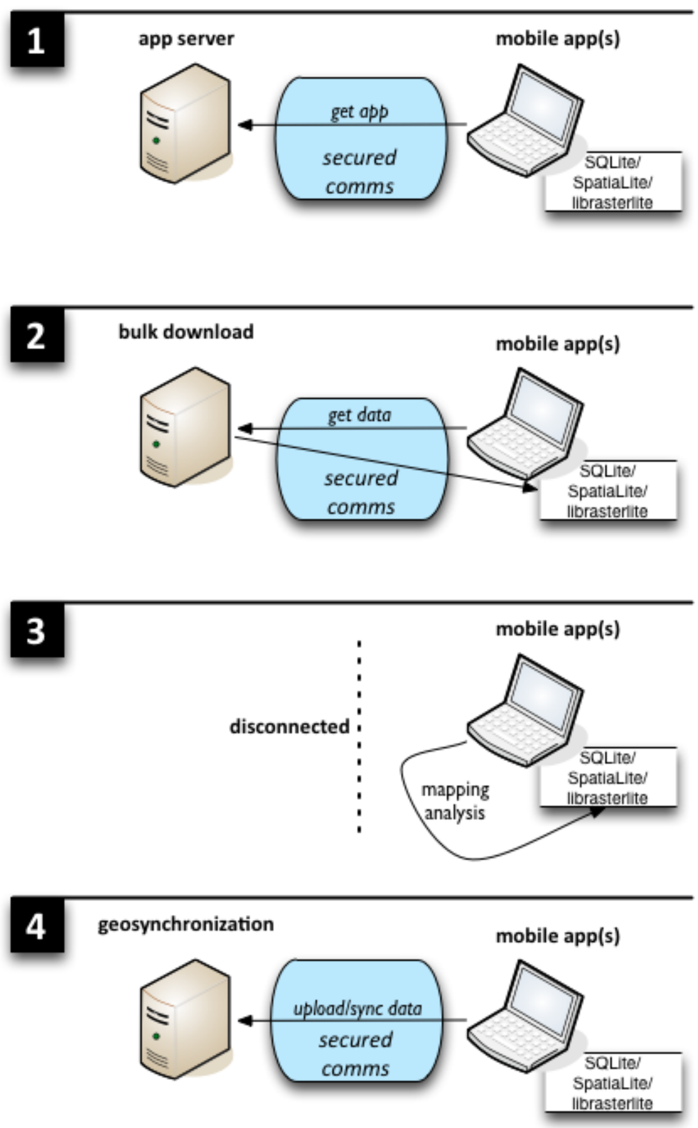

Figure 25 – Geospatial Mobile Applications Engineering Viewpoint

7.7.2 Web Mapping Engineering Viewpoint

The most important architecture of a map tiling service is that the world is segmented into a finite number of areas so that client and server software can build optimizations around the requests for those finite map tiles. These optimizations often involve caching data, which can happen on the client, the server, or somewhere in between.

A typical web map tile service interaction consists of the client requesting a number of map tiles from the service. The request first goes through Internet infrastructure equipment, such as routers, then finally gets the to service's web server, which interprets the request. The web server may decide to handle the request with cached data, or send the request on to a specialized application (a Web Map Tiling Server, Tiled Map Service, etc.) to prepare a response. The router(s) the request encountered along the way may also be able to interpret the request and handle it with cached resources.

If the request reaches the tiled map service, then the response will come out of a set of tiled map images, but a request handled out of cache is like any generic Internet resource, and simply looks like a piece of data whose HTTP header said it can be cached and used to satisfy identical requests for a certain period of time.

We also add metadata to the services model – namely those dealing with data quality and provenance – and prototype with WMS and WMTS services, and KML encoded files.

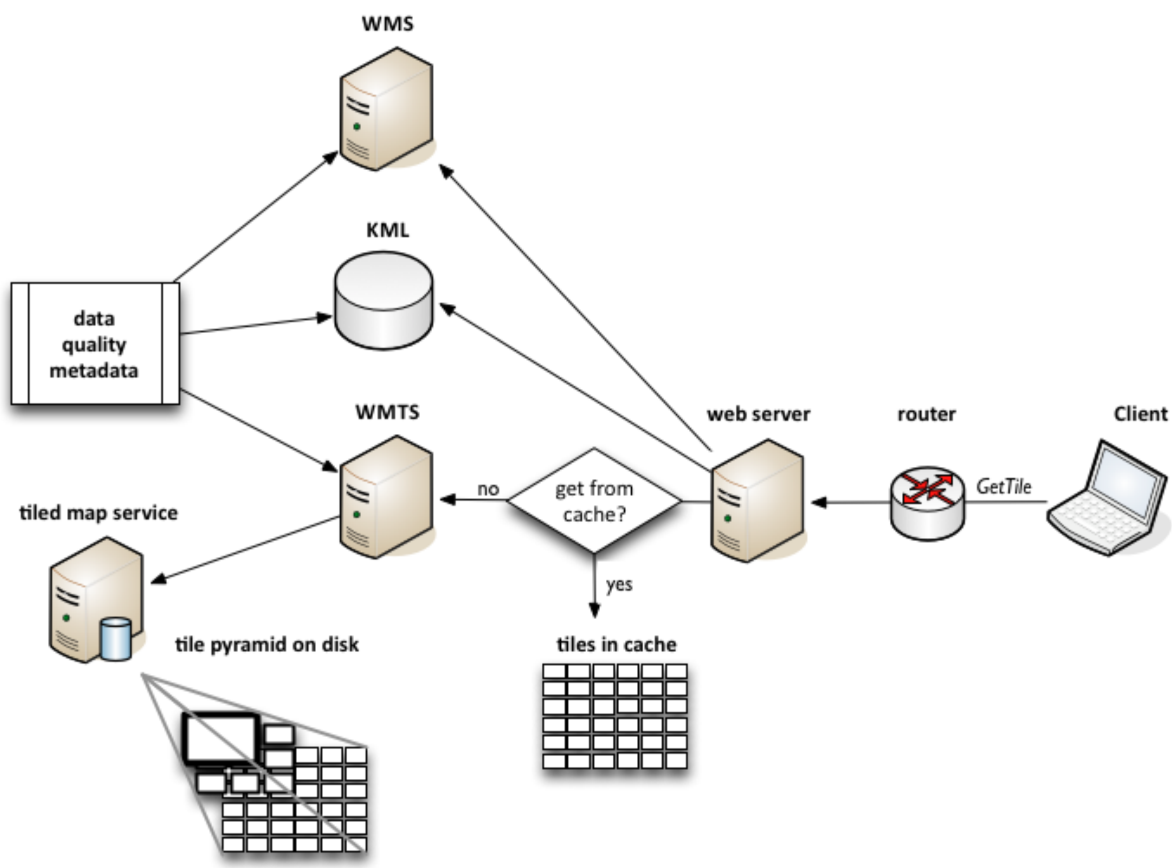

Figure 26 – Web Mapping Engineering Viewpoint

7.7.3 Coverage Access and Data Quality Engineering Viewpoint

In this sub-thread, we exercise the Web Coverage Service heavily. What is novel is the types of data we prototype with.

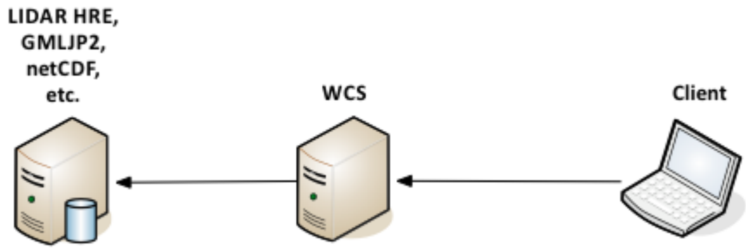

Figure 27 – Coverage Access and Data Quality Engineering Viewpoint

7.7.4 GPS Study Engineering Viewpoint

The primary work of this sub-thread is investigating the metadata associated with accuracy information on GPS data. Encoding these metadata is an end unto itself. However, if it proves practical to describe GPS metadata in an encoding that is already amenable to access from an OGC service interface, then GPS data and metadata can be exploited to its highest potential through integration into a proven architecture for interoperable geospatial information. Therefore, in addition to evaluating the traditional format for managing these data, VMF, we look also at the SWE Common Data Model and the Sensor Observation Service for treating GPS data as observations from sensors.

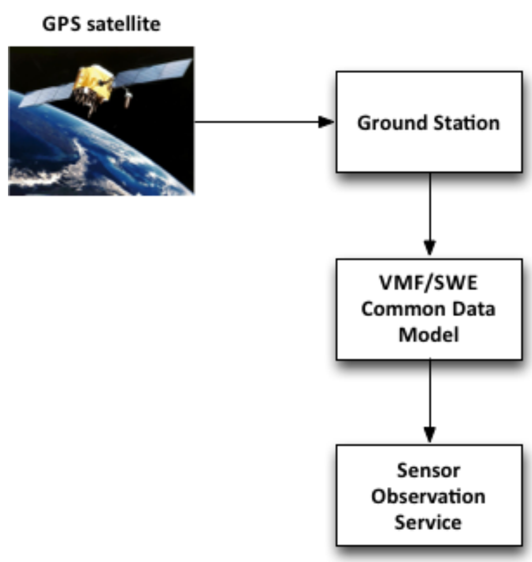

Figure 28 – GPS Study Engineering Viewpoint

8 OWS-9 Thread: CITE

8.1 CITE Thread Background

The OWS-9 work based on the Compliance & Interoperability Testing & Evaluation (CITE) program will advance OGC and industry vendors to develop, test and validate interface specifications, which are anticipated to lead to commercial products suitable for use by NGA, its customers and the broader federal geospatial community.

The goal of the CITE program, is to increase systems interoperability while reducing technology risks. It accomplishes this by providing a process whereby compliance for OGC standards can be tested. This program provides a mechanism by which users and buyers of software that implements OGC standards can be certain that the software follows the mandatory rules of implementation as specified in the standard. Vendors gain confidence that they are providing a product compliant with OGC standards, which will be easier to integrate and easier to market. Buyers gain confidence that a compliant product will work with another compliant product based on the same OGC standard, regardless of which company developed the product.

The CITE program uses The Test, Evaluation, And Measurement (TEAM) Engine, which is a test script interpreter Java application. It executes test scripts written in Compliance Test Language (CTL). All the tests for OGC standards are written in CTL.

Advancement of the capabilities of the OGC CITE program is necessary to provide sufficient testing and reporting to allow "buyers (to) gain confidence that a compliant product will work with another compliant product". In order to understand the capabilities of OGC compliant commercial software products and provide insight into potential interoperability issues between vendor implementations, additional tests suites are required and reporting capabilities bust me advanced.

OGC currently provides about 15 tests suites (including tests in the beta web site), but there are about 40 standards available. This thread will increase the testing capacity of the CITE program.

Implementers should be able to test for mandatory and non-mandatory tests. Implementers and buyers should be able to get better information about the test or the certification of a software. For example TEAM Engine should provide details of which conformance classes (group of tests) passed not passed or were not tested. Reporting capabilities will also be advanced in this thread.

8.2 CITE Thread Scope

The CITE thread will develop a suite of compliance test scripts for testing and validation of products with interfaces implementing the OGC specifications listed below. These scripts will be written for new Testing, Evaluation, and Measurement (TEAM) engine in CTL. The participants in this thread will develop test scripts. These Test scripts will be presented to the Technical Committee and Planning Committee for approval. All development activities within the CITE thread should result in products that are fully functional on a Linux platform on the OGC IT infrastructure.

The OWS-9 CITE Thread will develop Compliance elements in these areas:

- WMS 1.3 Server
- WMS 1.3 Client
- WFS 2.0
- GML 3.2.1
- OWS Context 1.0
- SWE
- WCS –EO 1.0
- TEAM Engine Capabilities

8.3 CITE Thread Requirements

References

- Compliance Program Policy and Procedures

- Compliance website

8.3.1 WMS 1.3 Server

8.3.1.1 Update of WMS 1.3 Compliance Test Scripts

Evaluate and update existing Compliance Test Scripts to test for all mandatory and optional elements.

8.3.1.2 Update WMS 1.3 reference implementation

- Add capabilities for Feature Portrayal Service,
- Add capabilities supporting Web Map Tiling Service

8.3.2 WMS 1.3 Client

8.3.2.1 Revise Client Testing scripts for WMS 1.3

Test Scripts exist in the beta TEAM Engine Web Site. Tests need to be revised for completeness. Submitting on addendum detailing the Client Testing capabilities to the WMS 1.3 specification may be required. The following should be performed:

- Specify a set of operations for a client to be tested.
- Enable reporting about expected operations that the client didn't performed
- Perform a comprehensive revision to make sure that the current WMS 1.3.0 client CTL tests take into account all the WMS 1.3.0 client-related requirements.
- Configure it as a standalone test suite, not embedded in the WMS 1.3 suite.
- Advise on required TEAM Engine changes to fulfill this task.

8.3.2.2 Develop a new reference implementation for WMS 1.3 client

The reference implementation is open source software that passes all the tests. The reference implementation will be advance in parallel as the progress of the tests.

8.3.3 WFS 2.0

8.3.3.1 Develop new reference implementation for WFS 2.0

The reference implementation is open source software that passes all the tests. The reference implementation will be advance in parallel as the progress of the tests.

8.3.3.2 Develop Compliance Test Scripts for WFS 2.0 including Filter Encoding 2.0

Develop of Compliance Test Scripts including tests for dependencies with other standards, which do not require a standalone test. The tests shall be designed in such a way as to test for all mandatory and optional elements.

8.3.4 GML 3.2.1

8.3.4.1 Develop Compliance Test Scripts for GML 3.2.1 including the ability to test application schemas.

OGC members have requested the need for testing encodings. There is already some work performed with SensorML and a GML validator. This task will advance a coherent GML testing for communities to use.

8.3.5 OWS Context 1.0

8.3.5.1 Develop Compliance Test Scripts for OWS Context 1.0

Develop of Compliance Test Scripts including tests for dependencies with other standards, which do not require a standalone test. The tests shall be designed in such a way as to test for all mandatory and optional elements.

8.3.6 SWE

8.3.6.1 Develop new reference implementation for SOS 2.0

The reference implementation is open source software that passes all the tests. The reference implementation will be advance in parallel as the progress of the tests.

8.3.6.2 Develop new reference implementation for SPS 2.0

8.3.7 WCS – EO 1.0

8.3.7.1 Complete WCS-EO testing

Complete the work started in OWS-9.This includes:

- Finalize format encoding extensions (GeoTIFF, JPEG2000, NetCDF), add HDF
- Finalize CRS extension (include ATS & ETS)
- Establish WCS band subsetting extension, including ATS & ETS
- Establish WCS scaling & interpolation extension, including ATS & ETS
- Establish WCPS ATS & ETS
- Advice on TEAM Engine updates for modular specification (core and extension packages)

8.3.7.2 Develop reference implementation for EO-WCS

8.3.8 Advance TEAM Engine Capabilities

8.3.8.1 Improve TEAM Engine capability to handle modularity and profiles

Currently profiles are managed in TEAM Engine as a subset of one test suite. It is not possible to have multiple parents dependent test suites. Further development of TEAM Engine is necessary to allow expressing of profiles as test suites but with the capability to import other tests (e.g. the dependencies). This will avoid code duplication and will align better the TEAM Engine capabilities with the Modular Specification.

8.3.8.2 Improve TEAM Engine build process

Currently TEAM Engine build process is not getting automatically the available tests suites at the OCC SVN. This needs to be configuring manually. The build process should automatically get information from all the tests in a particular directory and configure the welcome page and others automatically.

8.3.8.3 Provide a capability to invoke TEAM Engine via the Web

Currently to run a test suite, there are 2 choices: 1) using the web site, and 2) using command line. Calling a test via a URL will improve the usability of TEAM Engine and will allow to run test suites dependencies.

8.3.8.4 Develop a mechanism to allow parameterization of tests with custom data and schemas.

Some Test Suites (e.g. WFS 1.1) use "test" application schemas and test data. To make this test more useful and to allow the user community to truly understand whether their service implementation is OGC compliant, it is necessary to provide a mechanism whereby a user can provide their own data set and their own schema for use in the test script. It is required to evaluate and develop a mechanism whereby test data and application schemas are parameterized so a community can insert their own data and schemas.

The mechanism will be implemented with WFS 2.0 and WFS 1.1, including GML 3.1.1 and GML 3.2.1. It may be necessary to submit change requests or addendums related to the simplification and the re-architecture of current WFS 1.1 test suite,

8.3.8.5 Advance reporting capabilities

Enhance the reporting capabilities such that a "buyer" can determine whether an implementation supports each element of a standard both mandatory and optional. Test reports shall indicate a pass/fail for any portion of the test, which was executed, and a "not supported" for any portion of the test not executed.

The solution should follow the new Modular Specification, which requires specifying the conformance classes that were passed when testing implementation software.

8.3.8.6 Develop Documentation about CITE

Develop "OWS-9 CITE Help Guide Engineering Report" to be considered as a candidate OGC Best Practice document describing how to execute the CITE tests, how to select the mandatory and optional elements, how to access and download the TEAM Engine, Test Scripts and Reference Implementations, how to insert your own data and/or schemas along with a section for list of Frequently Asked Questions.

8.4 CITE Thread Deliverables

CITE deliverables differ slightly from other threads and should follow these guidelines:

- **Test Suites** are Executable Tests Suites as define in the CITE P&P. They are scripts and code developed at the OGC CITE SVN. They should follow the structure of other existing tests. The deliverable takes form of a new revision committed, tested and properly documented.
- **TEAM Engine enhancements** should be developed at the Sourceforge SVN. The deliverable takes form of a new revision committed, tested and properly documented
- The **reference implementation** is required to be Open Source. The reference implementation needs to pass the mandatory tests and other optional elements as specified.

The Deliverables are summarized in the Table with descriptions of the Deliverables in paragraphs following the table.

Table 5 – CITE Thread Deliverables Summary

1. WMS 1.3 Sever Test Suite update
2. WMS 1.3 Server Reference implementation update
3. WMS 1.3 Client Test suite update
4. WMS 1.3 Client Reference Implementation
5. WFS 1.1 Server Tests update - parameterizations
6. WFS 2.0 Server Reference implementation
7. WFS 2.0 Server Test Suite including Filter Encoding 2.0
8. GML 3.2.1 Test Suite
9. OWS Context 1.0 Test Suite
10. SOS 2.0 Server Reference Implementation
11. SPS 2.0 Server Reference Implementation
12. WCS EO 1.0 Server Test Suite update
13. WCS EO 1.0 Server Reference Implementation
14. TEAM Engine revision – user defined data and schemas
15. TEAM Engine revision – modularity, build process, web invocation
16. TEAM Engine revision – reporting
17. OWS-9 CITE Help Guide Engineering Report
18. Change Request, as needed

8.4.1 WMS 1.3 Sever Test Suite update

Evaluate and update existing Compliance Test Scripts to test for all mandatory and optional elements.

8.4.2 WMS 1.3 Server Reference implementation update

Evaluate and update existing Compliance Test Scripts to add capabilities for Feature Portrayal Service and add capabilities supporting Web Map Tiling Service.

8.4.3 WMS 1.3 Client Test suite update

Evaluate and update existing WMS 1.3 Compliance Test Scripts to: Specify a set of operations for a client to be tested, enable reporting about expected operations that the client didn't performed, perform a comprehensive revision to make sure that the current tests take into account all the WMS 1.3.0 client-related requirements, and configure it as a standalone test suite (i.e. not embedded in the WMS 1.3 suite).

8.4.4 WMS 1.3 Client Reference Implementation

Develop a client reference implementation for WMS 1.3 tests developed in the thread. It should at least pass all the mandatory tests

8.4.5 WFS 1.1 Server Tests update – parameterizations

Provide test revisions, as needed to support parameterizations of tests with custom data and schemas

8.4.6 WFS 2.0 Server Reference implementation

Develop a client reference implementation for WFS 2.0 tests developed in the thread. It should at pass all the mandatory and optional tests.

8.4.7 WFS 2.0 Server Test Suite including Filter Encoding 2.0

Develop compliance Test Scripts for WFS 2.0, including FE 2.0. The tests shall be designed in such a way as to test for all mandatory and optional elements.

8.4.8 GML 3.2.1 Test Suite

Develop compliance Test Scripts for GML 3.2.1. May include the development of test data and proper design to allow various levels of testing, from simple GML to more complex GML.

8.4.9 OWS Context 1.0 Test Suite

Develop compliance Test Scripts for OWS Context 1.0. The tests shall be designed in such a way as to test for all mandatory and optional elements

8.4.10 SOS 2.0 Server Reference Implementation

Develop a client reference implementation for SOS 2.0 tests developed in the thread. It should at pass all the mandatory and available optional tests.

8.4.11 SPS 2.0 Server Reference Implementation

Develop a client reference implementation for SPS 2.0 tests developed in the thread. It should at pass all the mandatory and available optional tests.

8.4.12 WCS EO 1.0 Server Test Suite

Update of compliance test scripts to finalize the work advance in OWS-8, as follows:

- Finalize format encoding extensions (GeoTIFF, JPEG2000, NetCDF), add HDF
- Finalize CRS extension (include ATS & ETS)
- Establish WCS band subsetting extension, including ATS & ETS
- Establish WCS scaling & interpolation extension, including ATS & ETS
- Establish WCPS ATS & ETS
- Advice on TEAM Engine updates for modular specification (core and extension packages)

8.4.13 WCS EO 1.0 Server Reference Implementation

Develop a client reference implementation for WCS WO 1.0 tests developed in the thread. It should at pass all the mandatory and available optional tests.

8.4.14 TEAM Engine revision – user defined data and schemas

Provide a mechanism whereby a user can provide their own data set and their own schema for use in the test script. It is required to evaluate and develop a mechanism whereby test data and application schemas are parameterized so a community can insert their own data and schemas. The mechanism will be implemented with WFS 2.0 and WFS 1.1, including GML 3.1.1 and GML 3.2.1.

8.4.15 TEAM Engine revision – modularity, build process, web invocation

Improve TEAM Engine to allow expressing of profiles as test suites but with the capability to import other tests (e.g. the dependencies). Profile tests should be able to be executed in a similar way as a standard alone test is currently being executed.

Improve TEAM Engine to automate the build process to get all the information of the tests form the SVN repository.

Improve TEAM Engine so the tests and configuration parameters can be invoked via URL. This tasks also includes update of some tests (WFS and WMS) to support this invocation.

8.4.16 TEAM Engine revision – reporting

Update TEAM engine to support detail reporting of test and conformance classes executed (pass, fail and not executed) for mandatory and optional tests.

8.4.17 OWS-9 CITE Help Guide Engineering Report

Develop "OWS-9 CITE Help Guide Engineering Report" to be considered as a candidate OGC Best Practice document describing how to execute the CITE tests, how to select the mandatory and optional elements, how to access and download the TEAM Engine, Test Scripts and Reference Implementations, how to insert your own data and/or schemas along with a section for list of Frequently Asked Questions.

8.5 CITE Enterprise Viewpoint

The CITE thread provides a framework to test conformance of software components to OGC specifications. The foundation of this framework lies in the globally dispersed data exchange technologies provided by the Internet and World Wide Web. The Compliance Engine for an OGC specification accepts one or more Compliance Test Suites. These suites will be run against a candidate OGC-compliant software component. The results of the test will be codified in a Compliance Test Report, indicating success or failure and as much detail as possible regarding the reasons for such.

Passing the compliance tests means that a product should be interoperable with any other product that passes the same tests. In practice, compliance is not sufficient to guarantee interoperability, due to slight differences in implementations and imprecision in the original specification, combined with variances in performance that certain data sets may expose. This is why integration experiments and plugfests are key components of interoperability testing. However, compliance testing is a necessary, crucial step along this continuum.

8.6 CITE Information Viewpoint

The primary information concepts in CITE are the test suite, test script, a test, and an assertion. A test suite is a collection of test scripts that validate compliance with a named technology. The technology may be an OGC implementation specification, an encoding specification, or a profile or subset of either.

A test script is a collection of tests that validate compliance with a particular Web service operation. The test scripts are written in the Compliance Test Language (CTL). A test is written in XML covering one assertion, or statement of required behavior that is derived from a specification. Tests typically contain one or more requests that are sent to the service begin tested, and XPath expression(s) that are evaluated against the results to determine whether the test passed or failed.

The test files also contain textual information describing the assertion being tested and how the test is performed. The engine automatically assembles this information to generate an assertions document describing each test the test suite is capable of performing.

In addition to the tests, the engine can be configured to prompt the user for information in the form of "scopes" which determine which tests will be executed for the session, or "variables", which can be used in the tests themselves.

8.7 CITE Computational Viewpoint

Compliance TEAM Engine can be depicted as client to OGC services, since it performs the standard operations on the OGC compliant server for testing purposes.

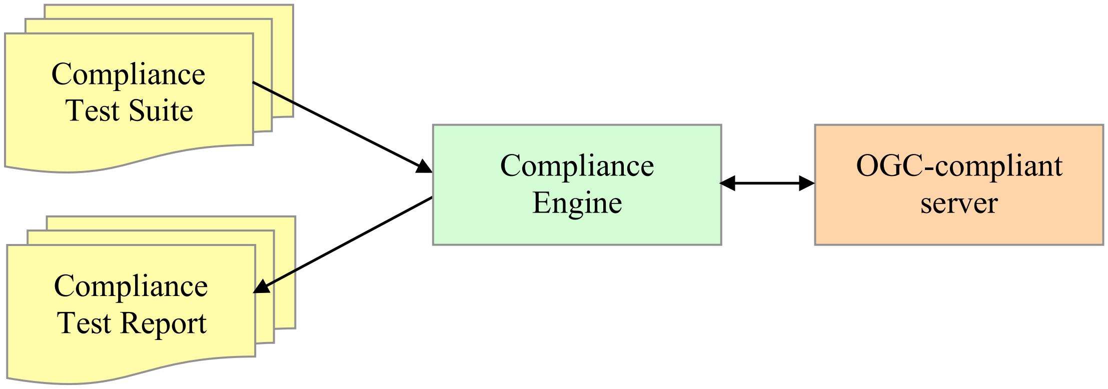

Figure 29 – Compliance Test Computational Viewpoint

8.8 CITE Engineering Viewpoint

Figure 30 below depicts the architecture of the TEAM engine. In developing tests for the engine, participants have the option to extend the engine's functionality by writing custom functions and parsers.

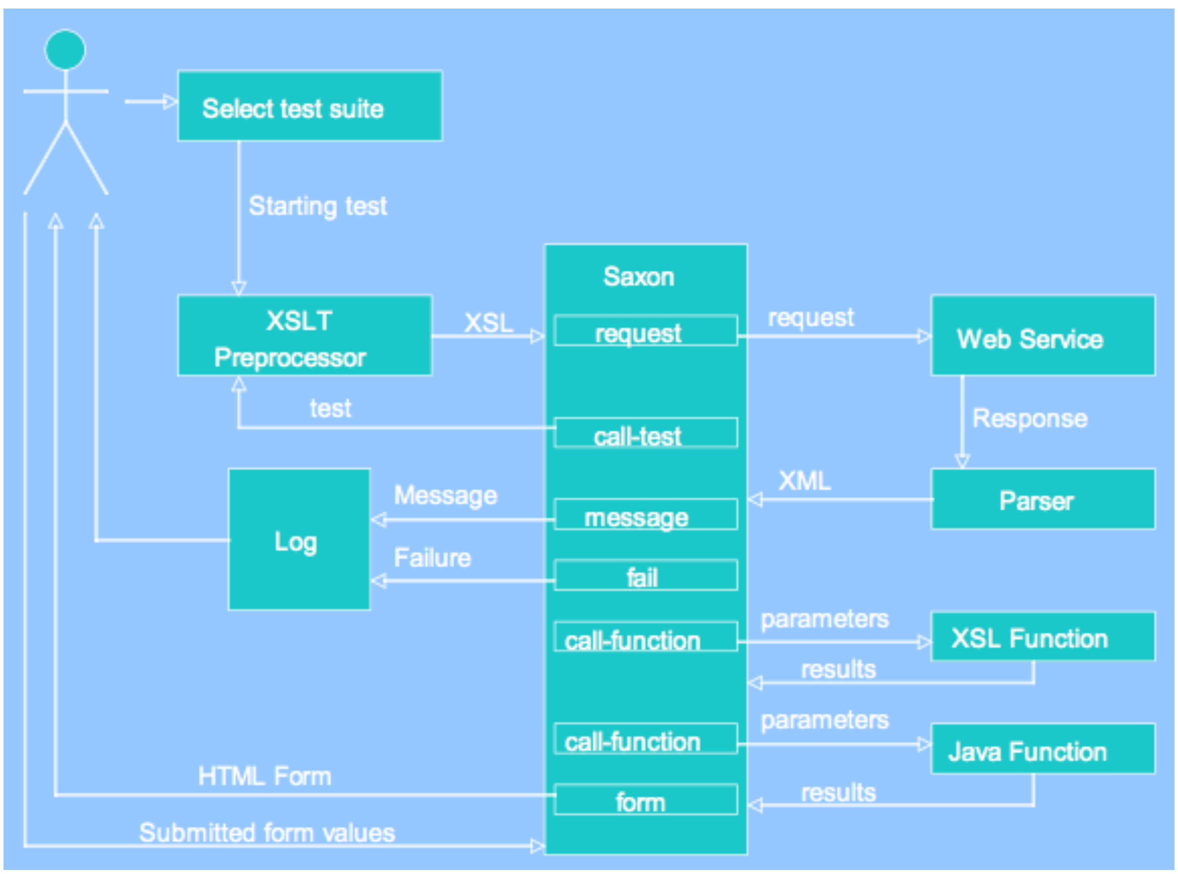

Figure 30 – Engineering viewpoint of the TEAM engine

9 Appendix: GPS Support Function Descriptions

9.1 Filter Function

Filter will run continuously at 5-min intervals. *Filter* restarts at timelines already processed and with appropriate events added will be used to reprocess data spans for which anomalies are present. As each reprocessed timeline is completed. These will continue to be generated rapidly until *Filter* catches back up with real time.

Products Manager will then generate a product structure with the contents as defined below. As each reprocessed timeline is completed, *Products Manager* will generate an updated product structure and send it to the Product Distribution Service (PDS).

For each satellite (by SVN/PRN):

- Center-of-mass orbit information - a posteriori inertial and Earth-fixed center-of-mass positions and velocities and inertial RAC position and velocity sigmas
- Antenna orbit information – antenna ID (L12), antenna offsets, and a posteriori inertial and Earth-fixed antenna phase center positions and velocities
- Attitude information – a priori body-fixed-to-ECI rotation matrix and rate of change of body-fixed-to-ECI rotation matrix, a posteriori ECI-to-RAC rotation matrix, and a priori yaw angle and yaw angle rate
- Clock information - a posteriori clock parameters and their sigmas and a clock event indicator if necessary
- Radiation pressure information - a priori Earth and Lunar eclipse indicators, shape factor, Sun elevation angle, Sun rotation angle, and Sun-Vehicle-Earth angle. A posteriori radiation pressure parameters and their sigmas
- Thrust information (when present) - thrust type (RAC) and a posteriori thrust parameters and their sigmas. Thrust start and end times and estimation end time
- Health flag
- Decoupled flag
- Measurement information by type
    - Mask status
    - Number of measurements processed in *Filter*
    - Number of measurements tagged (not processed)
    - RMS of the measurement residuals
    - Signal-to-noise ratio of the measurement residuals
- Event indicators (if necessary)

For each station (by ID/name):

- Station coordinate information –
    - Epoch data – reference epoch for station position and velocity, WGS 84 ECEF reference point position and velocity at this epoch, WGS 84 geodetic longitude, latitude, and height of reference point at this epoch, ENU reference point velocity at this epoch, height of antenna reference point (ARP) above station reference point, and height of antenna phase center above ARP
    - A posteriori ECEF XYZ-to-ENU rotation matrix
    - A priori XYZ and ENU tidal corrections
    - A posteriori XYZ and ENU station coordinate corrections and their sigmas (if station coordinates being estimated)

- Clock information - a posteriori clock parameters and their sigmas and a clock event indicator if necessary
- Tropospheric refraction information – number of parameters estimated and their total values and sigmas, and dry and wet zenith model values
- Weather information – temperature, pressure, relative humidity, and dew point temperature and their sources
- Decoupled flag
- Measurement information by type
  - Mask status
  - Number of measurements processed in *Filter*
  - Number of measurements tagged (not processed)
  - RMS of the measurement residuals
  - Signal-to-noise ratio of the measurement residuals
- Event indicators (if necessary)

Other:
- Earth orientation information
  - Earth Orientation Reference Model name (includes Effectivity Date and Bulletin Number)
  - A posteriori ECI-to-ECEF rotation matrix (ABCD) and its rate of change (AB'CD)
  - For each Earth orientation parameter (x, y, and UT1-UTC): total value, model value, diurnal/semi-diurnal correction, estimated offset and sigma, and estimated rate and sigma
  - IERS UT1-UTC information (when present)
    - Predicted value used as measurement
    - A priori residual and sigma
    - A posteriori residual and sigma
  - Greenwich sidereal time/right ascension of Greenwich
  - GPS-UTC time offset
- Master clock or composite clock selection
  - Platform ID or IDs
  - Weighting factor if clock part of composite clock (=1 if Master)
  - Clock event indicators (if necessary)
- Other event indicators (if necessary)
- Measurement information by type
  - Mask status
  - Number of measurements processed in Filter
  - Number of measurements tagged (not processed)
  - RMS of the measurement residuals
  - Signal-to-noise ratio of the measurement residuals
- Satellite, Earth orientation, between-satellite, and between satellite-and-Earth orientation blocks of full a posteriori covariance matrix for all estimated satellite-related parameters
- Station, Earth orientation, between-station, and between-station-and-Earth orientation blocks of full a posteriori covariance matrix for all estimated station-related and Earth orientation parameters
- Combined signal-to-noise ratio of all measurement residuals

From *Filter* output the following data products are produced:

1. **Near-real time Performance Assessment File (NPAF) (available in near-real time) -** GPSOC-defined XML file containing differences between the EPOCHA *Filter* Earth-fixed antenna phase center position and velocity and clock time and frequency offset estimates and those derived from the navigation messages at a given timeline for all satellites. Also contains the IODEs for the navigation messages used in computing the differences.
2. **Performance Assessment File (PAF) -** GPSOC-defined XML file containing the same information as **NPAF** except it includes all timelines within a specified time span.
3. **SP3-c File** – ASCII file containing Earth-fixed antenna phase center (or center-of-mass) position and velocity and clock time and frequency offset estimates at all timelines within a specified time span for all satellites.

9.2 Short-Term Predictor Function

Short-Term Predictor (*STP*) will run after each *Filter* timeline is completed and *Products Manager* will generate a product structure with the contents as defined below for a 2-hr prediction span at 5-min intervals and send it to the PDS. This is called “Navigation Message Replacement” mode. If *Filter* is restarted a few timelines into the past, *STP* can optionally recompute predictions and *Products Manager* will generate updated product structures and send them as soon as possible to the PDS. *STP* also has a mode called “Prediction” mode in which it will run at 15-min intervals and generate predictions for a 6-hr span at 15-min intervals.

For each “Prediction” mode run, *Products Manager* will again generate a product structure with the contents as defined below.

For each satellite (by SVN/PRN):

- Center-of-mass orbit information - predicted inertial and Earth-fixed center-of-mass positions and velocities and inertial RAC position and velocity sigmas
- Antenna orbit information – antenna ID (L12), antenna offsets, and predicted inertial and Earth-fixed antenna phase center positions and velocities
- Attitude information – body-fixed-to-ECI rotation matrix and rate of change of body-fixed-to-ECI rotation matrix, a posteriori ECI-to-RAC rotation matrix, and yaw angle and yaw angle rate
- Clock information - predicted clock parameters and their sigmas
- Radiation pressure information - Earth and Lunar eclipse indicators, shape factor, Sun elevation angle, Sun rotation angle, and Sun-Vehicle-Earth angle. Predicted radiation pressure parameters and their sigmas
- Thrust information (when present) - thrust type (RAC) and predicted thrust parameters and their sigmas. Thrust start and end times and estimation end time
- Health flag at time of prediction
- Prediction quality indicator (TBD)
- Decoupled flag at time of prediction

Other:

- Earth orientation information

  - Earth Orientation Reference Model name (includes Effectivity Date and Bulletin Number)
  - Predicted ECI-to-ECEF rotation matrix (ABCD) and its rate of change (AB'CD)
  - For each Earth orientation parameter (x, y, and UT1-UTC): total predicted value, model value, diurnal/semi-diurnal correction, predicted offset and (optional) sigma, and predicted rate and (optional) sigma
- Other event indicators (if necessary)
- (Optional) Satellite, Earth orientation, and between satellite-and-Earth orientation blocks of predicted covariance matrix for each individual satellite

From *Short-Term Predictor* output the following data products are produced:

1. **Navigation Message Replacement (NMR) File (available in near-real time)** – GPSOC-defined XML file containing navigation message parameters for all satellites derived by fitting to the 2-hr *STP* predictions for each satellite
2. **Predicted Ephemeris/State Vector Data (PRED) File (available in near-real time)** – GPSOC-defined XML file containing ECI center-of-mass position and velocity and clock time and frequency offset predictions at 15-min intervals for a 6-hr span for all satellites. No Earth orientation and antenna offset information are included in this message format
3. **SP3-c File** – ASCII file containing Earth-fixed antenna phase center (or center-of-mass) position and velocity and clock time and frequency offset predictions at all timelines within the *STP* prediction span for each output

9.3 Smoother Function

After *Filter* has completed processing the timeline at the middle of each day, *Smoother* will run and smooth the *Filter* results backwards for two days.

Products Manager will then generate a product structure with the contents as defined below and send it to the PDS. This is the Smoothed product for the previous day.

For each satellite (by SVN/PRN):

- Center-of-mass orbit information - smoothed inertial and Earth-fixed center-of-mass positions and velocities and smoothed inertial RAC position and velocity sigmas
- Antenna orbit information – antenna ID (L12), antenna offsets, and smoothed inertial and Earth-fixed antenna phase center positions and velocities
- Attitude information – body-fixed-to-ECI rotation matrix and rate of change of body-fixed-to-ECI rotation matrix (same as Filter), ECI-to-RAC rotation matrix, and yaw angle and yaw angle rate (same as Filter)
- Clock information - smoothed clock parameters and their sigmas and clock event indicator if necessary
- Radiation pressure information – Earth and Lunar eclipse indicators, shape factor, Sun elevation angle, Sun rotation angle, and Sun-Vehicle-Earth angle (same as Filter). Smoothed radiation pressure parameters and their sigmas
- Thrust information (when present) - thrust type (RAC) and smoothed thrust parameters and their sigmas. Thrust start and end times and estimation end time

- Health flag (same as Filter)
- Decoupled flag (same as Filter)
- Measurement information by type
  - Mask status
  - Number of measurements processed in Filter
  - Number of measurements tagged (not processed)
  - RMS of the measurement residuals
  - Signal-to-noise ratio of the measurement residuals
- Event indicators (if necessary, same as Filter)

For each station (by ID/name):

- Station coordinate information –
  - Epoch data – reference epoch for station position and velocity, WGS 84 ECEF reference point position and velocity at this epoch, WGS 84 geodetic longitude, latitude, and height of reference point at this epoch, ENU reference point velocity at this epoch, height of antenna reference point (ARP) above station reference point, and height of antenna phase center above ARP (same as Filter)
  - ECEF XYZ-to-ENU rotation matrix
  - XYZ and ENU tidal corrections (same as Filter)
  - Smoothed XYZ and ENU station coordinate corrections and their sigmas (if station coordinates being estimated)
- Clock information - smoothed clock parameters and their sigmas and clock event indicator if necessary
- Tropospheric refraction information – number of parameters estimated and their smoothed total values and sigmas, and dry and wet zenith model values
- Weather information – temperature, pressure, relative humidity, and dew point temperature and their sources (same as Filter)
- Decoupled flag (same as Filter)
- Measurement information by type
  - Mask status
  - Number of measurements processed in Filter
  - Number of measurements tagged (not processed)
  - RMS of the measurement residuals
  - Signal-to-noise ratio of the measurement residuals
- Event indicators (if necessary, same as Filter)

Other:

- Earth orientation information
  - Earth Orientation Reference Model name (includes Effectivity Date and Bulletin Number) (same as Filter)
  - Smoothed ECI-to-ECEF rotation matrix (ABCD) and its rate of change (AB'CD)
  - For each Earth orientation parameter (x, y, and UT1-UTC): total value, model value, diurnal/semi-diurnal correction, smoothed estimated offset and sigma, and smoothed estimated rate and sigma
  - Smoothed Greenwich sidereal time/Right ascension of Greenwich
  - GPS-UTC time offset
- Master clock or composite clock selection (same as Filter)
  - Platform ID or IDs
  - Weighting factor if clock part of composite clock (=1 if Master)
  - Clock event indicators (if necessary)

- Other event indicators (if necessary, same as Filter)
- Measurement information by type
  - Mask status
  - Number of measurements processed in Filter
  - Number of measurements tagged (not processed)
  - RMS of the measurement residuals
  - Signal-to-noise ratio of the measurement residuals
- Satellite, Earth orientation, between-satellite, and between satellite-and-Earth orientation blocks of full smoothed covariance matrix for all estimated satellite-related parameters
- Station, Earth orientation, between-station, and between-station-and-Earth orientation blocks of full smoothed covariance matrix for all estimated station-related and Earth orientation parameters
- Combined signal-to-noise ratio of all measurement residuals
- Corrected measurements – for each measurement:
  - Type
  - Satellite SVN
  - Station ID
  - Correction flags
  - Value
  - Sigma

From *Smoother* output the following data product is produced:

1. **SP3-c File** – ASCII file containing Earth-fixed antenna phase center (or center-of-mass) position and velocity and clock time and frequency offset smoothed estimates at all timelines within the *Smoother* time span for all satellites

9.4 Long-Term Orbit Predictor Function

Long-Term Orbit Predictor (*LTOP*) will run after each *Smoother* is completed

Products Manager will then generate a product structure with the contents as defined below for the entire 9-day prediction span at 15-min intervals starting at the end of the *Smoother* span and send it to the PDS.

For each satellite (by SVN/PRN):

- Center-of-mass orbit information - predicted inertial and Earth-fixed center-of-mass positions and velocities and inertial RAC position and velocity sigmas
- Antenna orbit information – antenna ID, antenna offsets, and predicted inertial and Earth-fixed antenna phase center positions and velocities
- Attitude information – body-fixed-to-ECI rotation matrix and rate of change of body-fixed-to-ECI rotation matrix, a posteriori ECI-to-RAC rotation matrix, and yaw angle and yaw angle rate
- Radiation pressure information - Earth and Lunar eclipse indicators, shape factor, Sun elevation angle, Sun rotation angle, and Sun-Vehicle-Earth angle. Predicted radiation pressure parameters and their sigmas

- Thrust information (when present) - thrust type (RAC) and predicted thrust parameters and their sigmas. Thrust start and end times and estimation end time
- Health flag at time of prediction
- Prediction quality indicator (TBD)
- Decoupled flag (on if flag set at any time during Smoother span used for computing predictions)

Other:

- Earth orientation information
  - Earth Orientation Reference Model name (includes Effectivity Date and Bulletin Number)
  - Predicted ECI-to-ECEF rotation matrix (ABCD) and its rate of change (AB'CD)
  - For each Earth orientation parameter (x, y, and UT1-UTC): total predicted value, model value, diurnal/semi-diurnal correction, predicted offset and sigma, and predicted rate and sigma
- Other event indicators (if necessary)
- Predicted covariance matrix for each satellite and predicted covariance for Earth orientation parameters

From *Long-Term Orbit Predictor* output the following data product is produced:

1. **SP3-c File** – ASCII file containing Earth-fixed antenna phase center (or center-of-mass) position and velocity predictions at all timelines within the *LTOP* prediction time span for all satellites

10 Appendix: Systems Rules Model

Systems rules are constraints on a system(s), a system hardware/software item(s), or a system function(s). The following outlines what the system must do, or what it cannot do. At the systems or system hardware/software items level, this describes the rules under which the systems behave under specified conditions.

10.1 MAINTAIN DATA SYNCHRONIZATION BETWEEN GROUND AND AIRCRAFT USERS

The pilot-in-command and the dispatcher are jointly responsible in operations that fall under 14 CFR Part 121 Air Carrier Certification (relevant excerpts of Part 121 are included in section 10.7). An important aspect of satisfying this requirement is the ability to share information to ensure both are making well-informed decisions. This may be interpreted as ensuring that each is aware of the data that is being shared with the other party.

This set of System Rules addresses a set of functionalities that is applicable to satisfying the ***OWS-9 Aviation Develop interoperable data transmission to aircraft management*** *requirement.*

Configuration Options	Context / Description / Rationale
Send copies to the dispatch client of all data sent to the aircraft	Ensures all parties receive the same data.
Send the type or class of data sent to the aircraft to the dispatch client with sufficient information to enable the dispatch client to request the data. Could be implemented by sending unique "hash tag-like" metadata to the dispatch client of all the data sent to the aircraft.	Minimizes bandwidth by sending only the types, classes, and metadata to the dispatch client.
Send copies to the dispatch client of selected types or classes of data sent to the aircraft.	Enables the dispatch client to subscribe to copies of the data sent to the aircraft for discrete sets of data or data products, e.g. NOTAMs or weather.

Table 6 -- Maintain Data Synchronization between Ground and Aircraft Users

10.2 PERFORM DATA VALIDATION – RULES ARE APPLIED BY BOTH THE DMS AND THE AIRCRAFT

This set of System Rules addresses a set of functionalities that is applicable to satisfying the ***OWS-9 Aviation Develop interoperable data transmission to aircraft management*** *requirement.*

Metric	Definition(s)	Requirements

Timeliness #1	Data is delivered within its valid timeframe	- DMS and EFB software shall evaluate message content for start and end date/times to determine whether the message data needs to be flagged when sent to the aircraft or presented to the user.
		Note *– applying this evaluation at the aircraft will identify messages that are within valid time frame when transmitted but not when received at the aircraft.*
		- Software shall enable the user to set a parameter for acceptable range of variance from valid time frame for transmitting information to the aircraft.
		- Software shall set the Data Validation Data element appropriate valid time frame code as noted below:
		    o Within valid time frame
		    o Outside valid time frame
		- Software shall maintain percent of failures and reports via the Monitor/Report Network Performance function as a percent per 1,000 messages:
		1,000 minus # of out-of-valid time frame msgs
		Divided by
		1,000

Metric	Definition(s)	Requirements

Timeliness #2	Data represents the most up-to-date information	- DMS software shall track and reference all updates using the time they are issued (regardless of the effective time(s) of the changes) until the time of reception to identify the most up-to-date information.
		- DMS and EFB software shall transmit new or updated information to the cockpit as soon as it becomes available at the approved source.
		- User shall be enabled to set a parameter for acceptable range of variance from time for transmitting information to the aircraft as measured from the issue date/time of the message until received.
		- DMS software shall populate the Data Validation Data element code with appropriate timeliness factor code, as noted below:
		  o Meets timeliness factor
		  o Exceeds timeliness factor
		- The network performance metric shall be defined as communications performance for transmission of information from the data source to the cockpit. This performance metric will be defined by intended function and operational use.
		- Software shall determine whether messages meet currency time frame requirement as measured from issue date / time through delivery date / time to aircraft. Software shall maintain percent of failures and report via the Monitor/Report Network Performance function:
		1,000 minus # of msgs not meeting time frame
		Divided by
		1,000

Metric	Definition(s)	Requirements

Timeliness #3	Subscribed update intervals are being complied with	• Software shall monitor update intervals to ensure they are being complied with using transmission date time groups (DTGs) as the criteria for determining the actual intervals.
		• Software shall populate the Data Validation Data element code with appropriate timeliness factor code, as noted below:
		  o Meets subscribed interval
		  o Exceeds subscribed interval
		• User shall be enabled to set a parameter for acceptable range of variance from subscribed update intervals
		• Software maintains percent of failures and reports via the Monitor/Report Network Performance function:
		1,000 minus # of subscription intervals
		missed by more than __ seconds
		Divided by
		1,000

Metric	Definition(s)	Requirements
Lost Data – applies to all modes of operation ▯ Broadcast ▯ demand ▯ contract	Determine whether any messages or data sets were lost	▯ DMS software shall evaluate message content and context to determine that a message has been lost, e.g., refers to prior content such as NOTAM, TFR that has not been received, and populates the lost data code in the Data Validation Data Set. ▯ Software shall populate the Data Validation Data element code with appropriate lost data code, as noted below: o No lost data o Previous message not received ▯ Software shall evaluate the frequency at which a message refers to prior content (e.g., NOTAM, SIGMET, TFR, etc.) that has not been received. Software maintains percent of failures and reports via the Monitor/Report Network Performance function: 1,000 minus # of lost messages/data sets **Divided by** 1,000

Table 7 -- Perform Data Validation

10.3 PERFORM DATA FILTERING

The purpose of this data filtering function is to pare down the incoming data stream into the specific data needed for a specific situation or use. Additionally, there are situations where data must be restricted from flowing to a specific user, e.g., data with redistribution restrictions or proprietary data. Filtering will be applied to data flowing from the DMS to the aircraft and from the aircraft to the DMS. It is anticipated that the data filtering profiles will be maintained by the DMS and uploaded to the EFB in consideration of aircrew workload for those situations where the aircraft is the data producer.

This set of System Rules addresses a set of functionalities that is applicable to satisfying the ***OWS-9 Aviation Develop interoperable data transmission to aircraft management and Advance interoperable data retrieval*** *requirements.*

Configuration Options	Context / Description / Rationale
By message type or class of data	Align with the Message Types from Populate Priority and Security Data Fields
By issue time for types for data– range of parameters	Range of parameters associated with the Message Types
By effective time for types of data – range of parameters	Range of parameters associated with the Message Types
If multiple values are available, enable selection of average value, standard deviation value, range of values, preferred provider(s)	For example, if multiple sensor sources are available and provided for an area, enable the user to select a means to reduce the data to a relevant value, e.g., multiple temperature sensors at an airport.
Enable selection or input of a specific geo-reference for sensor data	For example, user might select RVR for the eastern-most of two parallel runways because the swamp outside the airport tends to produce mist that reduces visibility for that runway.
By expiration time – range of parameters	Range of parameters associated with the Message Types
Enable selection of any data within a geo-referenced area, e.g. X miles either side of route and including vertical range for a 3-D area	The AOC can set this based on a pilot profile and can upload to the EFB. This geo-referenced area can also be pilot-selectable.
Enable selection of "Trend" for a specific event	This rule allows an operator to select a data point, e.g. weather event, and indicate how much history of the event is desired for a trending display.

Configuration Options	Context / Description / Rationale
Enable no filtering at all	In the case of a DMS to DMS transfer of data, the entire data set would be transmitted.
Filter on security level code	The security code populated in the Populate Priority and Security Data Fields section is used to ensure that appropriate data safeguards are imposed on the data received by the aircraft or the DMS.

Table 8 -- Data Filtering

10.4 MANAGE SUBSCRIPTION AND DATA REQUEST CONFIGURATIONS

This set of System Rules addresses a set of functionalities that is applicable to satisfying the ***OWS-9 Aviation Develop interoperable data transmission to aircraft management and Advance interoperable data retrieval*** *requirements.*

System Rule	Context / Description / Rationale
DMS and EFB systems shall contain configurable profiles for subscriptions and data requests that are managed by both the aircrew and the dispatcher	Subscriptions have a couple of characteristics that have an impact: - They publish a complete stream of data. - They publish updates to a data set. In the latter case, the subscriber must perform a data request to ensure it has a current copy of the complete data set that can then be updated. The profiles associated with this system rule enable the user to designate which subscriptions require a "pre-load" of the complete data set and then to request that data.
Configuration profiles shall be capable of alignment with specific flight plans.	Configuration profiles will be used repetitively for common routes.
Users shall be able to store profiles keyed at least to flight or route and pilot.	Configuration profiles will be used repetitively for common routes and pilots may have specific needs for specific data or different parameters, e.g., miles to either side of the route.
Configuration profiles shall enable the user to plan deviations from a flight plan or establish ad hoc situations for obtaining needed flight planning information.	As part of both pre-flight and en route strategic planning, dispatchers and pilots will need to be obtain data that support these planning activities.
Update interval timeframes shall be configurable by subscription, e.g., NAS program or other source of data	The user will establish update intervals that support his or her need for frequency of data.
Request-response configurations shall be enabled for those subscriptions that require a pre-load of the data when updates only are issued with the subscription	Data request-response configurations are important because in many instances activation of a subscription only provides updates. In those instances, activation of the subscription must also be accompanied for a data request to pre-load a baseline of the data.
User shall be able to select data sets that are not on the flight plan, e.g., select specific items or events, or expand the geospatial scope of the subscription.	As part of both pre-flight and en route strategic planning, dispatchers and pilots will need to be obtain data that support these planning activities.

System Rule	Context / Description / Rationale
Subscription parameters associated with a configuration profile shall be capable of being downloaded to an EFB.	In consideration of aircrew workload, subscription profiles need to be pre-loaded into the EFB.

Table 9 -- Subscription and Data Request Configurations

10.5 POPULATE PRIORITY AND SECURITY DATA FIELDS

Information needs to be developed and transmitted with messages to enable "in-stream systems" to provide information to the aircraft on the importance and priorities of messages, data re-distribution limitations, and service level agreements associated with communication technologies.

*This set of System Rules addresses a set of functionalities that is applicable to satisfying the **OWS-9 Aviation Develop interoperable data transmission to aircraft management** requirement.*

Title	System Rules	Context / Description / Rationale

Message Importance / Priority	• High-importance and short-to-expire messages shall be sent before low-importance and long-to-expire messages.
	• Software shall evaluate message content to determine its priority and populate the appropriate field in the Data Validation Data Set:
	  o Evaluate expiration time for less than specified number of minutes
	  o Evaluate by Message Type to set priority
	  o Evaluate by request priority to set delivery priority
		In a bandwidth-restricted environment, it is important to identify messages that have greater priority based on their importance and type.

Message Type	• Software shall determine type of message from the header information or content and assign appropriate code as noted in the following examples:
	  o Airport conditions, e.g., braking action, congestion
	  o NAS Equipment Status
	  o NAVAID Status
	  o NOTAM
	  o SAA Status / Schedule
	  o Runway configuration data
	  o Etc.
		In order to support the Message Importance / Priority metric, the types of messages need to be defined.

Title	System Rules	Context / Description / Rationale

Security Level	• Software shall determine how data may be used, displayed, or retransmitted based on the terms of the data exchange agreement with the data provider
	• Software shall populate a security code in the appropriate field in the Data Validation Data set as noted in the following examples:
	  ○ Encryption required
	  ○ Company proprietary
	  ○ Limited data redistribution
	  ○ Classified – Secret
	  ○ etc.
		The data provider may impose restrictions on the use and redistribution of data, aviation operators may impose limitations on distribution and use of their data and the operational environment may require additional security restrictions.
		
		This field may be populated by either the DMS or the aircraft:
		• DMS to accommodate the terms of its data distribution agreements or the need to safeguard company proprietary data
		• Aircraft primarily to safeguard company proprietary data being sent from the aircraft to the DMS and potentially to a NAS program.

Data Link SLA	• DMS software shall determine the data link that is being used to transmit the message and populate the field as noted in the following examples:
	  ○ Vendor SLA1
	  ○ Vendor SLA2
	  ○ Vendor SLAn
	• Vendor SLA1 through n – indicates the established performance associated with specific transmission technologies that are being used to transmit data to and from the aircraft.
		This code expresses the terms of the data link type that is associated with a specific message and represents the SLA level for the reliability, consistence, validity, etc. metrics.
		
		This is a function of the technology and the associated negotiated SLA that is used for transmitting the message.

Table 10 -- Populate Priority and Security Data Fields

10.6 DATA PROVENANCE

Data Provenance is an area that studies the evolution of data, including the source and authority of data creation, changes to the data along the life history of the data and the sources responsible in achieving those changes. It provides a qualitative and quantitative metric to analyze the quality and the dependability of the data, based on the consumer's trust of the source of creation and the sources that were responsible for modification.

This set of System Rules addresses a set of functionalities that is applicable to satisfying the ***OWS-9 Aviation Develop interoperable data transmission to aircraft management*** *requirement.*

System Rule	Context / Description / Rationale
The DMS software shall include metadata describing the authoritativeness of the source in messages sent to the aircraft	This allows the onboard software to make intelligent decisions about how the data is presented to the flight crew (i.e., if the data is not sourced with authority, inform the crew in some manner).
The DMS software shall provide a mechanism for recording provenance data.	There is a need for historical recall of data and metadata sent and received from aircraft for many purposes (e.g., accident investigation).
The DMS Provider shall establish a method for secure provenance between the NESG and the aircraft.	This ensures all points on the length of the data exchange can trust that the data received continues to have integrity (i.e., lack of corruption intentional or accidental). Additionally this ensures that when there is a breakdown in integrity, it can be identified where it occurred. In this instance secure provenance refers to providing integrity and confidentiality guarantees to information requiring provenance. In other words, secure provenance means to ensure that the data cannot be altered, and users can trace who else has performed actions on the data.
The DMS Provider shall enable operators to configure what type or class of information will have provenance associated with it.	In a bandwidth intensive environment some operators may elect to conserve bandwidth by limiting the types and classes of data that has provenance associated with it. It should be noted that some types and classes of data may eventually become required by regulation for security and safety purposes.

Table 11 -- Data Provenance

10.7 JOINT RESPONSIBILITY REFERENCES - EXCERPTS FROM 14 CFR PART 121 AIR CARRIER CERTIFICATION

121.533 Responsibility for operational control: Domestic operations.

(a) Each certificate holder conducting domestic operations is responsible for operational control.

(b) The pilot in command and the aircraft dispatcher are jointly responsible for the preflight planning, delay, and dispatch release of a flight in compliance with this chapter and operations specifications.

(c) The aircraft dispatcher is responsible for—

(1) Monitoring the progress of each flight;

(2) Issuing necessary information for the safety of the flight; and

(3) Cancelling or re-dispatching a flight if, in his opinion or the opinion of the pilot in command, the flight cannot operate or continue to operate safely as planned or released.

(d) Each pilot in command of an aircraft is, during flight time, in command of the aircraft and crew and is responsible for the safety of the passengers, crewmembers, cargo, and airplane.

(e) Each pilot in command has full control and authority in the operation of the aircraft, without limitation, over other crewmembers and their duties during flight time, whether or not he holds valid certificates authorizing him to perform the duties of those crewmembers.

[Doc. No. 6258, 29 FR 19219, Dec. 31, 1964, as amended by Amdt. 121–253, 61 FR 2613, Jan. 26, 1996]

And

§ 121.535 Responsibility for operational control: Flag operations.

(a) Each certificate holder conducting flag operations is responsible for operational control.

(b) The pilot in command and the aircraft dispatcher are jointly responsible for the preflight planning, delay, and dispatch release of a flight in compliance with this chapter and operations specifications.

(c) The aircraft dispatcher is responsible for—

(1) Monitoring the progress of each flight;

(2) Issuing necessary instructions and information for the safety of the flight; and

(3) Cancelling or re-dispatching a flight if, in his opinion or the opinion of the pilot in command, the flight cannot operate or continue to operate safely as planned or released.

(d) Each pilot in command of an aircraft is, during flight time, in command of the aircraft and crew and is responsible for the safety of the passengers, crewmembers, cargo, and airplane.

(e) Each pilot in command has full control and authority in the operation of the aircraft, without limitation, over other crewmembers and their duties during flight time, whether or not he holds valid certificates authorizing him to perform the duties of those crewmembers.

(f) No pilot may operate an aircraft in a careless or reckless manner so as to endanger life or property.

[Doc. No. 6258, 29 FR 19219, Dec. 31, 1964, as amended by Amdt. 121–253, 61 FR 2613, Jan. 26, 1996]

And

§ 121.537 Responsibility for operational control: Supplemental operations.

(a) Each certificate holder conducting supplemental operations—

(1) Is responsible for operational control; and

(2) Shall list each person authorized by it to exercise operational control in its operator's manual.

(b) The pilot in command and the director of operations are jointly responsible for the initiation, continuation, diversion, and termination of a flight in compliance with this chapter and the operations specifications. The director of operations may delegate the functions for the initiation, continuation, diversion, and termination of a flight but he may not delegate the responsibility for those functions.

(c) The director of operations is responsible for cancelling, diverting, or delaying a flight if in his opinion or the opinion of the pilot in command the flight cannot operate or continue to operate safely as planned or released. The director of operations is responsible for assuring that each flight is monitored with respect to at least the following:
(1) Departure of the flight from the place of origin and arrival at the place of destination, including intermediate stops and any diversions there from.
(2) Maintenance and mechanical delays encountered at places of origin and destination and intermediate stops.
(3) Any known conditions that may adversely affect the safety of flight.

(d) Each pilot in command of an aircraft is, during flight time, in command of the aircraft and crew and is responsible for the safety of the passengers, crewmembers, cargo, and aircraft. The pilot in command has full control and authority in the operation of the aircraft, without limitation, over other crewmembers and their duties during flight time, whether or not he holds valid certificates authorizing him to perform the duties of those crewmembers.

(e) Each pilot in command of an aircraft is responsible for the preflight planning and the operation of the flight in compliance with this chapter and the operations specifications.

(f) No pilot may operate an aircraft, in a careless or reckless manner, so as to endanger life or property.

[Doc. No. 6258, 29 FR 19219, Dec. 31, 1964, as amended by Amdt. 121–253, 61 FR 2613, Jan. 26, 1996]