OGC®
Open Geospatial Consortium

Technology Office
4899 North Old State Road 37
Bloomington, IN 47408
Telephone: +1-812-334-0601
Facsimile: +1-812-961-2053

Request for Quotation (RFQ)
And
Call for Participation (CFP)
OGC Web Services Initiative - Phase 8 (OWS-8)

Annex B
OWS-8 Architecture

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1 OWS-8 Introduction

A significant part of OGC is the Interoperability Program (IP), which conducts international initiatives such as Test beds, Pilot Projects, Interoperability Experiments, and Interoperability Support Services. These are all designed to encourage rapid development, testing, validation, 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 8 (OWS-8) is a Test bed within the Interoperability Program. This is a global, hands-on and collaborative prototyping activity designed for rapid development and delivery of Service-Oriented Architecture (SOA) components and services, as well as experience leading to documented best practices. The results of this program are initially documented as Engineering Reports and submitted to OGC's Technical Committee for consideration as discussion papers, candidate specifications, and best practices. Upon formal adoption within the OGC Specification Program, standards and best practices are then made publicly available. Discussion papers may also be made publicly available, with the understanding that these do not represent a formal position of the OGC.

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-8 development, which involves multiple interdependent activity threads. The requirements and architectures presented here are based upon a collaborative effort between OWS-8 Sponsors and OGC's IP program and project management staff, called the IP Team. The OWS-8 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-8 development threads.

Section 3 discusses the architectural approach and technical baseline for OWS-8.

Section 4 discusses the architectural approaches and issues for each of the OWS-8 development threads.

For ease of navigation, section numbers and page numbers that appear in the text body are hyperlinks to those locations.

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-8 Initiative Threads

In July of 2010, the OGC issued a call for sponsors for the OWS-8 interoperability initiative to advance OGC's open framework for interoperability in the geospatial industry. Three meetings were conducted with potential OWS-8 sponsors to review the OGC technical baseline, discuss OWS-7 results, and identify OWS-8 requirements. During the OWS-8 Concept Development phase, a Fusion Standards Study (begun in OWS-7) was also completed, to better inform the requirements for OWS-8 development.

2.1 Fusion Standards in OWS-8

References

- *Fusion Standards Study Engineering Report,* OGC Document 09-138, 2010-03-21, http://portal.opengeospatial.org/files/?artifact_id=36177 (public document)
- *Fusion Standards Study, Phase 2 Engineering Report,* OGC Document 10-184, 2010-11-11 (this will be made a public document during the RFQ response period; contact the OGC Technology Desk (techdesk@opengeospatial.org) for access)

The purpose of the Fusion Standards Study was to review existing standards regarding information fusion, with a focus on geospatial information, and develop a set of recommendations for future standards and integration of other standards. Results of the study are contained in the two OGC Engineering Reports cited above. The definition of fusion resulting from the study was:

> *"Fusion is the act or process of combining or associating data or information regarding one or more entities considered in an explicit or implicit knowledge framework to improve one's capability (or provide a new capability) for detection, identification, or characterization of that entity".*

There exist many fusion processes deployed in closed architectures with existing single provider software and hardware solutions. Fusion is not a new topic. The problem in the study was to move those capabilities into a distributed architecture based upon open standards including standards for security, authorization, and rights management.

In the study, fusion was discussed in terms of three categories, as depicted in Figure 2-1:

- Sensor Fusion: ranging from sensor measurements of various observable properties to well characterized observations including uncertainties. Fusion processes involve merging of multiple sensor measurements of the same phenomena (i.e., events of feature of interest) into a combined observation; and analysis of the measurement signature.
- Object/Feature Fusion: includes processing of observations into higher order semantic features and feature processing. Object/feature fusion improves understanding of the operational situation and assessment of potential threats and impacts to identify, classify, associate and aggregate entities of interest. Object/feature fusion processes include generalization and conflation of features.
- Decision Fusion: focuses on client environments for analysts and decision makers to visualize, analyze, and edit data into fusion products for an understanding of a situation in context. Decision fusion includes the ability to fuse derived data and information with processes, policies, and constraints. Collaboration with other analysts is done using social networking services and collaboration tools that are location enabled.

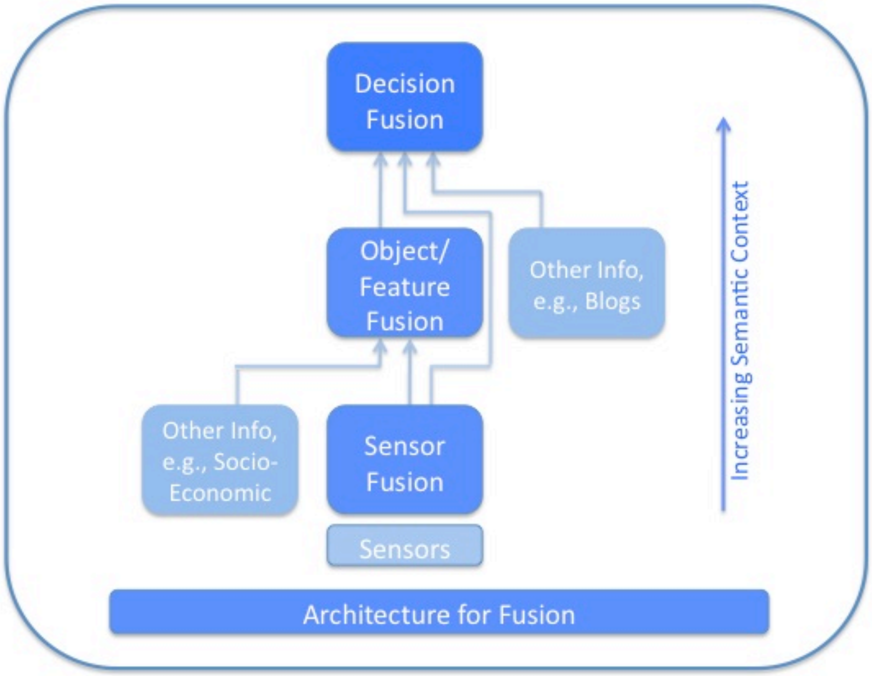

Figure 2-1. Categories of Fusion

As a result of this study, many of the tasks requested by sponsors of OWS-7 were organized into two of the testbed activity threads: Sensor Fusion Enablement, and Feature & Decision Fusion. The third thread was Aviation, addressing a number of fusion issues as well, in the areas of Aeronautical Information Management (AIM), weather data and event processing, and portrayal.

In OWS-8, we continue the emphasis on sensor and feature fusion, as well as aviation and weather, as shown in Figure 2-2. With the recent adoption of OGC Web Coverage Service (WCS) 2.0, there is strong interest among the sponsors to develop a community standard profile for Earth Observation applications that supports consistent usage of several coverage data formats in current use: netCDF (including CF/netCDF), GeoTIFF, HDF-EOS, JPEG2000, GML Simple Features Profile and GML Application Profile for Coverages. These requirements will be presented in detail in the Observation Fusion section of this Annex.

Another strong interest in Sensor/Observation Fusion for study in OWS-8 is in detecting and tracking moving objects that appear in a stream of motion imagery data. In OWS-7, there was a task to perform "change detection" between multiple tracks of motion imagery captured along the same route at different times. A related task in OWS-8 goes in a somewhat different direction: to identify an object (e.g., vehicle or person) that is moving through the field of view captured in the imagery stream. The WCS 2.0 tasks and Moving Object tasks represent distinct subthreads of the Observation Fusion Thread, but may be coordinated around a shared demonstration scenario, which will be determined during and after the OWS-8 Kickoff.

The Feature Fusion/Portrayal tasks shown in Figure 2-2 build on previous testbed tasks in feature and decision fusion. The Geosynchronization (Gsync) subthread builds on similar work in OWS-7, but with a different use case. Instead of assuming high-bandwidth Internet connectivity, the current task is to support transfer of data in network-austere environments. The bulk transfer could take place using portable media or FTP with data compression. Note that Aviation has a performance subthread, leading to a possible cross-thread topic for geodata compression.

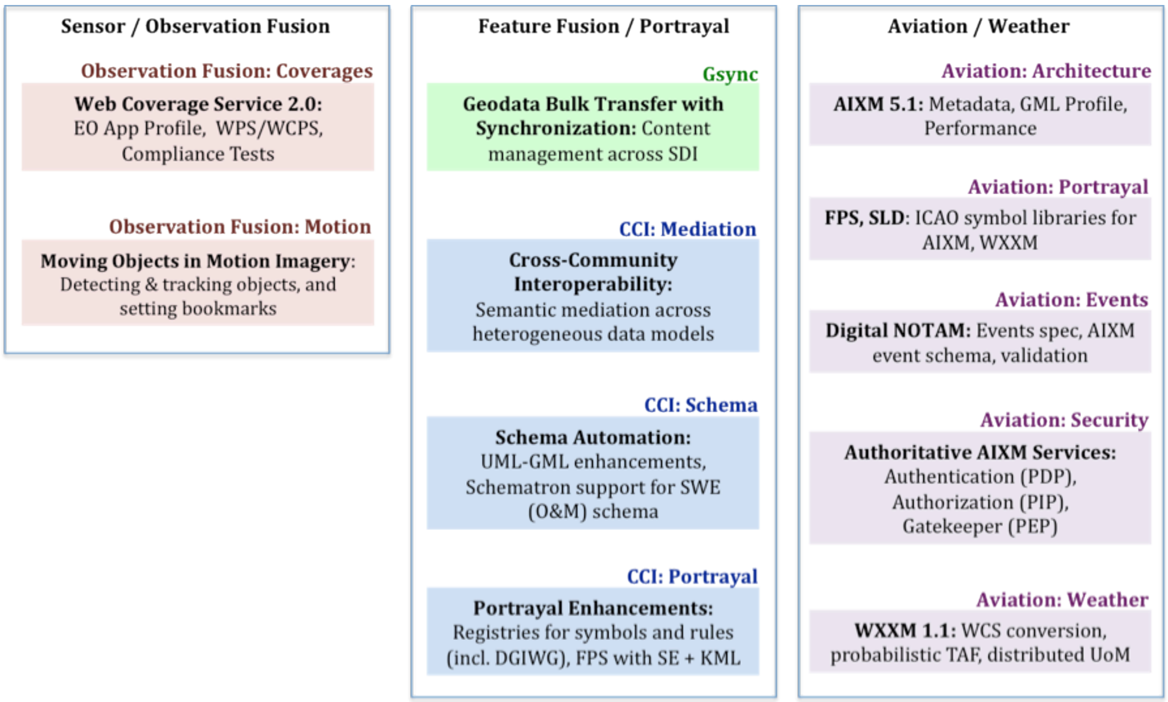

Figure 2-2. OWS-8 Activity Threads and Subthreads

Another set of feature fusion tasks are grouped into the Cross-Community Interoperability (CCI) thread, as shown in the figure. The schema automation and portrayal subthreads build on previous OWS-6 and OWS-7 tasks, but the semantic mediation subthread is a new topic. This will involve developing a coherent, harmonized approach for working with multiple data sources that have common scope but different feature type and attribute names and properties.

The Aviation Thread has a number of task areas in OWS-8. Some of these could become cross-thread topics, such as catalogue registries, portrayal, event architecture, and data compression, depending on how compatible the requirements are across the threads.

A more detailed introduction to each of these threads is given below, followed by a detailed discussion of the architectural implications of the initiative threads.

2.2 Observation Fusion Thread

The Observation Fusion Thread builds on the OGC Sensor Web Enablement framework that has achieved maturity through previous OWS interoperability initiatives and deployments worldwide. Emphasis in OWS-8 Observation Fusion is on moving-object detection and tracking in motion imagery streams, and on fusion of Earth Observation coverages.

The primary tasks for Observation Fusion during this OWS testbed will be the following:

- Implementing and reconciling NATO STANAG and NGA MISB standards for tracking moving objects in motion imagery, using OGC Standards. Investigate, evaluate and recommend areas of harmonization between OGC Sensor Web Enablement, OGC GML-based standards, and OGC Tracking and Notification Service, to support STANAG 4607 Ground Moving Target Indication Format (GMTIF), Edition 3; STANAG 4609, Edition 3, EG0903.0 Video Moving Target Indicator (VMTI); and NATO Study 4676 NATO ISR Tracking Standard (NITS).
- Document a set of architecture viewpoints showing the use of SWE and other OGC standards to implement the TCPED-based GMTI, VMTI, and ISR Tracking concept of operations. Document any gaps and shortfalls found in the architecturally relevant OGC suite of standards where implementations supporting GMTI, VMTI, and/or ISR Tracking would fall short of defined requirements. The OWS-8 ER on this topic could become the basis for an OGC Best Practice.
- WCS 2.0 EO-AP Definition and Implementation. Develop implementation experience with the draft WCS 2.0 Earth Observation Application Profile (EO-AP).
- WCS 2.0 EO-AP Compliance Testing. Develop Compliance Test suite for the WCS 2.0 AP including completing the ATS and developing the ETS and Reference Implementation.
- Processing of EO Coverages: WCPS and WPS. Develop WCPS for advanced access to Earth Observation Coverages. Develop WPS for Earth Observation data analysis of multiple coverages and other data.

For detailed Observation Fusion requirements and deliverables, see Section 4.2.

2.3 Geodata Bulk Transfer with Synchronization (Gsync) Thread

Gsync in OWS-8 builds upon OWS-7 work from the Feature and Decision Fusion (FDF) thread, and extends OWS-7 progress to cover key technology areas that could not be addressed within the scope of that initiative. In particular we seek to advance the state of geographic data sharing and synchronization. Past OGC initiatives devised the Geosynchronization specification, which is approaching final standards status. Testing in a variety of situations has identified the need to prototype synchronization mechanisms involving subsets of the full data set as a critical use case. Transfers under conditions of little or no network connectivity are also an important requirement. This test bed pursues that requirement. There is also a need to better define the range of validation, or quality assurance regimes that the Geosynchroniziation specification supports, adding functionality where needed, or simply developing best practices documents to explain how to implement the specification to achieve the appropriate goals.

The following task areas have been identified for the Gsync Thread:

- Geodata Bulk Transfer: The ability to distribute individual data sets and/or collections of data sets in a consistent manner offline and over networks.
- Geosynchronization: Web services and client components to support synchronization and updates of geospatial data across a hierarchical Spatial Data Infrastructure (SDI). OWS-8 enhances the work from OWS-7 to streamline

validation scenarios, bootstrap database creation and population, and define query-based subscription mechanisms.

For detailed Gsync thread requirements and deliverables, see Section 4.3.

2.4 Cross-Community Interoperability (CCI) Thread

The OWS-8 CCI thread also builds on and extends OWS-7 progress in the Feature and Decision Fusion Thread to cover key technology areas that could not be addressed within the scope of that initiative. This thread seeks to increase interoperability within communities sharing geospatial data, including advancing of interoperability among heterogeneous data models, advancing strategies to share styles to provide a more common and automated use of symbology, improvement of KML, and advancing schema automation allowing communities to better share there information artifacts. The main task areas are as follows:

- Advancement of semantic mediation approaches to query and use data based on different heterogeneous data models, which are available via OGC WFS.
- Advancement of the use of style registries and styling services.
- Advancement of the use of KML.
- Advancement of the use of UML/OCL for Schema Automation on Domain Models.

For detailed CCI thread requirements and deliverables, see Section 4.4.

2.5 Aviation

The Aviation Thread of OWS-8 builds on the Aeronautical Information Management (AIM) and Aviation threads of OWS-6 and OWS-7 respectively, 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.

The US Federal Aviation Administration (FAA) and EUROCONTROL have developed AIXM as a global standard for the representation and exchange of aeronautical information. AIXM was developed using the OGC Geography Markup Language (GML) tailored to the specific requirements for the representation of aeronautical objects, including the temporality feature that allows for time dependent changes affecting AIXM features. The overall objectives of the FAA and EUROCONTROL are to use AIXM as a basis for modernizing their aeronautical information procedures and transitioning to a net-centric, global aeronautical management capability. More specifically, AIXM is being used in the net-centric System Wide Information Management (SWIM)-related components of the US NextGen and European Union (EU)'s SESAR programs. As with OWS-6 and OWS-7, it is expected that the results of the Aviation Thread of OWS-8 will be contributed to both programs with a focus on recommended OGC specifications that can be applied in the definition and implementation of both SWIM environments.

As for WXXM, it is the proposed standard for the exchange of aeronautical weather information in the context of a net-centric and global interoperable Air Transport System (ATS). It is currently under development by FAA and EUROCONTROL in support of the

NextGen and SESAR programs. WXXM also uses GML tailored to the specific requirements of aeronautical meteorology and is based on the OGC Observation and Measurement Model. WXXM development is harmonized and coordinated with the World Meteorological Organization (WMO), the organization traditionally responsible for standards in meteorology.

By sponsoring the Aviation Thread in OWS-8, FAA and EUROCONTROL aim to increase industry adoption of these formats and to support the operational use and validation of these emerging standards.

In OWS-8, 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:

1. Advancement of AIXM in the areas of maturing the delivery, filtering and update of AIXM 5.1 using WFS-T/FE 2.0, continuing the development of reusable tools, benchmarking of compression techniques for enhanced performance, advancing styling and portrayal support, and validating the emerging metadata and GML profiles currently under development within the Aviation Domain Working Group (DWG),
2. Advancement of the architecture developed in OWS-6 and OWS-7 to further advance the Event Notification Architecture including support for the emerging Digital NOTAM Event Specification, use relevant concepts contained within the RTCA's SC-206 Operational Services and Environment Definition (OSED) for Aeronautical Information Services and Meteorological Data Link Services, and address the requirements for implementing an Authoritative Data Source for AIXM data,
3. Advancement of various concepts related to WXXM and weather information such as using coverages for encoding representative weather forecast and radar datasets, supporting on-demand Coordinate Reference System (CRS) specifications/transformations, exploring alternative distributed architectures for managing Units of Measure (UoM), demonstrating the applications of probabilistic Terminal Aerodrome Forecasts (TAF) decision making applications, and reviewing/validating the WXXM schemas.

To meet the above objectives, the Aviation Thread of OWS-8 will :

1. Build on the architecture, scenarios and results of the OWS-6 and OWS-7 testbeds;
2. Leverage, as needed, the architecture and services developed in the FAA SAA Dissemination OGC Pilot[1];
3. Coordinate with the OGC Aviation Domain Working Group (DWG) and the PubSub Standard Working Group (SWG) in support of meeting the thread requirements.

For detailed Aviation requirements and deliverables, see Section 4.5.

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[1] http://www.opengeospatial.org/standards/requests/72

3 OWS-8 Baseline

3.1 OpenGIS® Reference Model

Reference: OpenGIS® Reference Model version 2.0, document OGC 08-062r4

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

The OpenGIS 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-8 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-8.

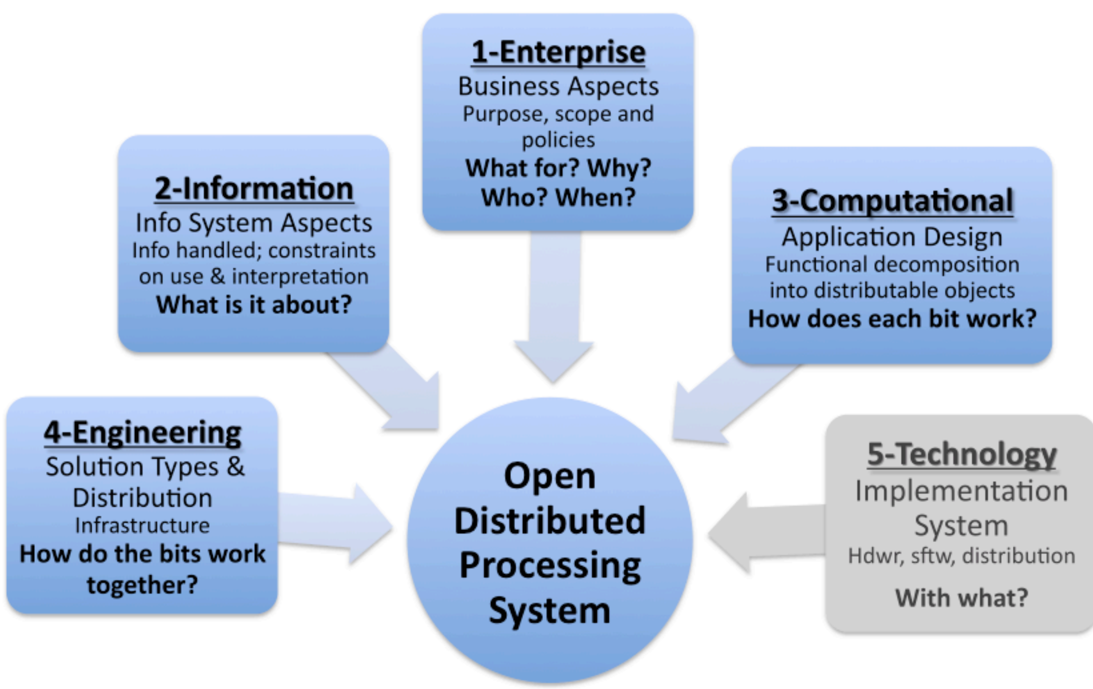


Figure 3-1. RM-ODP Viewpoints used in OGC Reference Model

3.2 OGC Standards Baseline

The OGC Standards Baseline, at any point in time, is the set of all Adopted Standards plus all other technical documents that have been made available to the public by the OGC Technical and Planning Committees. The Standards Baseline comprises 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 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-8 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

This document status was added to the Standards Baseline shortly before OWS-6 testbed, and contains all the Public Engineering Reports resulting from OWS-6 and OWS-7, making this a valuable resource for many of the tasks in OWS-8 which build on the previous testbeds' results. These are not all required or normative.

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.

3.6 Non-OGC Standards Relevant to Testbed Activities

Additional normative and informative references may be cited for specific requirements in some of the threads. If there is any question about the best or most current source for any such references, please contact the OGC Technology Desk, (techdesk AT opengeospatial.org).

4 OWS-8 Architecture

4.1 Fusion Standards Study

References

- *Fusion Standards Study Engineering Report,* OGC Document 09-138, 2010-03-21, http://portal.opengeospatial.org/files/?artifact_id=36177 (public document)
- *Fusion Standards Study, Phase 2 Engineering Report,* OGC Document 10-184, 2010-11-11 (this will be made a public document during the RFQ response period; contact the OGC Technology Desk (techdesk@opengeospatial.org) for access)

As mentioned in Section 2.1, a study of Fusion Standards in geospatial processing was completed during the OWS-8 Concept Development Phase. The goal of this study was to define and develop fusion standards for applied use in OGC testbeds, to give analysts an environment in which to use interoperable tools to analyze, process and exploit different types of data or products from the same or multiple sensors and databases from one client. The working definition of fusion from this study is the following:

> *"Fusion is the act or process of combining or associating data or information regarding one or more entities considered in an explicit or implicit knowledge framework to improve one's capability (or provide a new capability) for detection, identification, or characterization of that entity".*

4.1.1 Categories of Fusion

From this definition, fusion processes can apply to many types of entities. The main categories of fusion are based on the processing stage or semantic level at which fusion takes place, and are often divided as shown in Figure 4-1. The three categories of Fusion described in the Engineering Report were:

- Sensor Fusion: ranging from sensor measurements of various observable properties to well characterized observations including uncertainties. Fusion processes involve merging of multiple sensor measurements of the same phenomena (i.e., events of feature of interest) into a combined observation; and analysis of the measurement signature.
- Object/Feature Fusion: includes processing of observations into higher order semantic features and feature processing. Object/feature fusion improves understanding of the operational situation and assessment of potential threats and impacts to identify, classify, associate and aggregate entities of interest. Object/feature fusion processes include generalization and conflation of features.
- Decision Fusion: focuses on client environments for analysts and decision makers to visualize, analyze, and edit data into fusion products for an understanding of a situation in context. Decision fusion includes the ability to fuse derived data and information with processes, policies, and constraints. Collaboration with other analysts is done using social networking services and collaboration tools that are location enabled.

These categories of fusion are useful but are not completely distinct. Assigning a fusion process to a specific category is done as a convenience for explanation in this document and should not be considered a normative classification scheme.

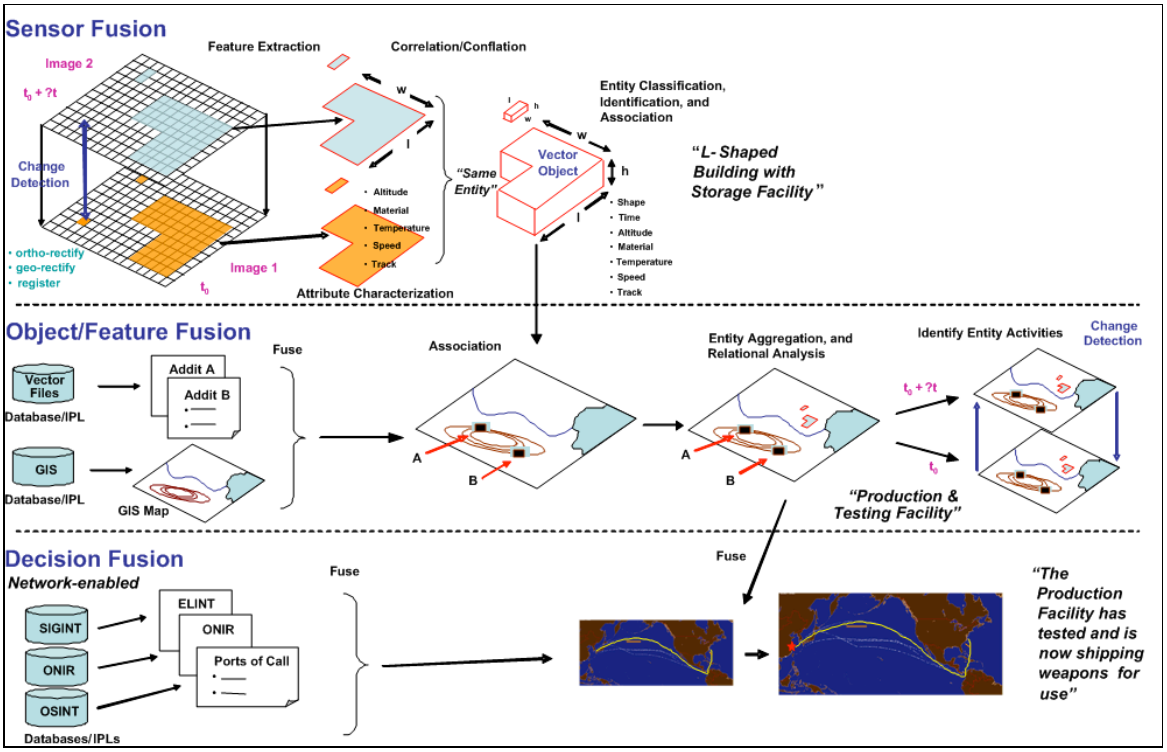


Figure 4-1. Categories of Fusion

4.1.2 Fusion Recommendations

The recommendations listed here in bullet form are discussed in detail in the Fusion Standards Study Engineering Reports.

Sensor Fusion

- Harmonization of the process of precise geolocation
- Online community sanctioned definitions for sensor terms
- Discovery and access of dynamic sensors
- Characterizing and propagating uncertainty of measurements
- Increasing use of geometric and electromagnetic signatures
- Fusion of video from airborne and ground based platforms
- Recognition and characterization of observed objects/features and events

Object/Feature Fusion

- Define a conceptual model of feature lifecycle – beyond conflation.
- Standardize metadata for provenance and uncertainty.
- Develop common data models supporting feature fusion.
- Define a portfolio of feature fusion services.
- Develop schema and encoding to support sharing of Track Features

Decision Fusion

- Develop an information model with decisions as a first class object
- Define interfaces and functionality for decision fusion engine component type
- Uncertainty propagation for a "hard fusion" topic
- "See and Talk" collaboration with common view
- Coordination through social networks
- Political Geography as a step to all information types
- Dynamic routing based on location

Architecture and Infrastructure

- Use of Open, Community IT Standards
- Semantics mediation of community vocabularies, taxonomies
- Workflow driven by semantics
- Grid and Cloud implementations for performance and access

These recommendations form the basis for the organization and many of the requirements of the OWS-7 and OWS-8 initiative threads. The Aviation Thread was not considered directly in the Fusion Standards Study, but benefits from cross-thread interactions with the other threads in areas such as event notification, workflow processing, geosynchronization, and decision support. These topics will be discussed below in the context of each thread.

4.2 Observation Fusion Thread

NOTE: Bidders should check for possible RFQ clarifications related to topics in this thread before submitting detailed responses. All questions and clarifications will be posted through December 15 at the latest, on the RFQ webpage: http://www.opengeospatial.org/standards/requests/74 .

4.2.1 Background

As a thread of activity in OWS-8, Observation Fusion thread combines the OGC Sensor Web Enablement (SWE) standards and architecture with the results of the recent OGC study of Fusion Standards, described in Sections 2.1 and 4.1. Sensor Fusion was one of three categories in of the Fusion Standards study. The Observation Fusion thread continues the further refinement and extension of SWE with an emphasis on sensor fusion.

The Sensor Web Enablement (SWE) architecture was designed to enable web-accessible sensor assets through common interfaces and encodings. Sensor assets may include the sensors themselves, observation archives, simulations, and observation processing algorithms. The role of SWE is depicted in Figure 4-2. The purpose of the OGC Sensor Web Enablement framework is to provide interoperability among disparate sensors and models, as well as to serve as an interoperable bridge between sensors, models and simulations, networks, and decision support tools.

SWE enables the creation of integrated sensor networks where all types of sensors, instruments, imaging devices and repositories of sensor data are discoverable, accessible and, where applicable, controllable via Web technologies and standards. In this vision, connections to sensors are layered with Internet and Web protocols and XML schemas are used to publish formal descriptions of the sensor's capabilities, location and interfaces. Web services for serving, brokering and consuming sensor data can then parse and evaluate sensor characteristics and observations based on their published descriptions. Information provided in XML about a sensor's control interface enables automated communication with the sensor system to determine, for example, its state and location, to issue controlling commands to the sensor platform, and to access its stored or real-time data.

SWE provides the basis for an open standards approach to Senor Fusion. Sensor Fusion considers sensor measurements of various observable properties to well characterized observations including uncertainties. Fusion processes involve merging of multiple sensor measurements of the same phenomena (i.e. events of feature of interest) into a combined observation; and analysis of the measurement signature.

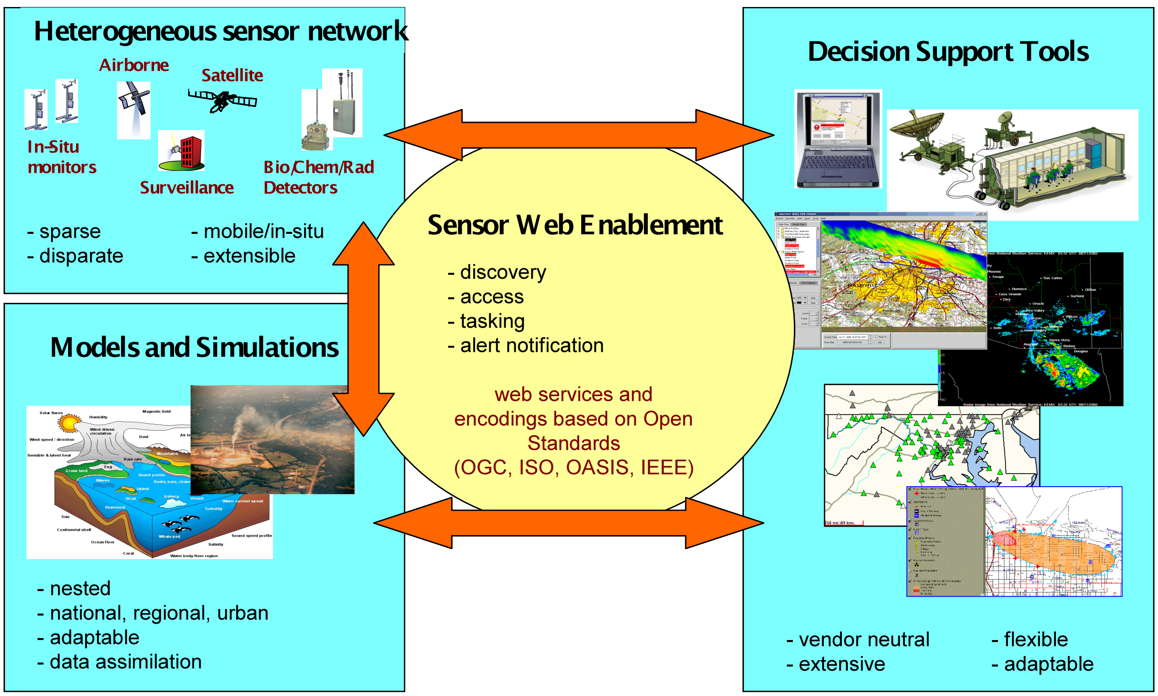


Figure 4-2. The Role of SWE

Sensor fusion concerns the acquisition and exploitation of multiple measurements for the purpose of:

- Obtaining a higher-level or more accurate measurement
- Recognizing objects and events of interest
- Determining properties of particular objects or events

Sensor fusion involves how measurements are made available to a fusion processes and how the fusion processes make use of the observations to create semantically higher order entities, e.g., geospatial features.

The Fusion Standards Study offered several recommendations to advance an open standards basis for fusion in a distributed information environment. The Sponsor Organizations have selected the following Sensor Fusion recommendations to be addressed in OWS-8:

1. Fusion of motion imagery from airborne and ground based platforms

Motion imagery from airborne (e.g., UAVs) and ground-based platforms provides a sensor source that both challenges many data handling systems, as well as provides opportunities for advanced fusion processing. Challenges include the need for common tasking interfaces for all UAVs and motion imagery systems, the difficulties in discovering coverages from highly dynamic sensor systems, the need for supporting large volumes of streaming data, the importance of efficient on-demand precise geolocation of video frames, the opportunity to derive 3D geometries from multiple frames, and the ability to derive advanced knowledge from temporal differences. It is recommended that profiles for airborne video be developed for SWE standards (particularly SensorML, O&M, SOS, and SPS) and that these be tested and demonstrated.

2. Recognition and characterization of observed objects/features and events

It is important to test and demonstrate whether existing standards and technologies can improve the connection between sensor measurements and the recognition and characterization of observed objects/features and events. The process of sensor fusion for the purpose of object recognition and characterization can challenge traditional systems that struggle with disparities between both sensor systems and community standards. It is recommended that testbeds be establish to test and demonstrate the application of SWE standards for improving sensor fusion across various sensor communities and agencies.

4.2.2 Observation Fusion Scope

The Observation Fusion Thread builds on the OGC Sensor Web Enablement framework that has achieved a degree of maturity through previous OWS interoperability initiatives and deployments worldwide.

Observation Fusion has two distinct subthreads: Moving Objects in Motion Imagery, and Coverages. See the Requirements sections below, for list of references by subthread.

4.2.2.1 Implementing GMTI, VMTI, and ISR Tracking with OGC Standards

Ground Moving Target Indicator (GMTI) is a radar-based Imagery, Surveillance, & Reconnaissance (ISR) product that provides detection information for objects moving on the surface of the earth, either on the ground or surface of a body of water. The detection information is generated by measuring the strength and Doppler shift of the "echo" of a transmitted pulse, upon receipt by either a co-located or separately-located receiver. By integrating the received information over several pulses, and processing the signal to remove return clutter resulting from non-moving objects, the position of the moving object and its relative range rate is measured. The relative range rate information is then translated to a speed and velocity indication. This detection is then registered and displayed onto a map or image, or input into an advanced processing stage that correlates or fuses multiple detections over time into tracks. The NATO standard for GMTI information is Standardisation Agreement (STANAG) 4607 Ground Moving Target Indicator Format (GMTIF), Edition 3. Video Moving Target Indicator (VMTI) is a video-based ISR product that, similar to GMTI, provides detection information for mobile objects on the surface of the earth, either on the ground or surface of a body of water. The phenomenology for VMTI differs significantly from GMTI in that detections are formed by a process of frame-to-frame change detection. The Motion Imagery Standards Board (MISB) and the STANAG 4609 Custodial Support Team (CST) has proposed a standard for VMTI, which is described in Engineering Guidance (EG) 0903.0. The VMTI Engineering Guidelines (MISB EG 0903.2) defines requirements for providing metadata to video clients to support situational awareness and provide input to the common operational picture (COP). The Video Moving Target Indicator (VMTI) Concept of Operations provides a view of VMTI within a Tasking, Collection, Processing, Exploitation, and Dissemination (TCPED) environment. ISR Tracking adds a correlation/fusion perspective for the moving object detections. In general, one or more sets of detection information are correlated or fused over time to produce tracks. More formally defined, a *track is a set of associated state vector estimates describing the time-sequenced location, velocity, acceleration, and other relevant characteristics of a mobile object or group of objects.* NATO has proposed a standard for transmitting and sharing track information in NATO Study 4676 NATO ISR Tracking Standard (NITS). The OGC SWE standards have been previously placed in a TCPED framework. This work item focuses on two specific areas of requirements: first, identifying and documenting OGC standards and/or other relevant open standards to meet the GMTI, VMTI, and ISR Tracking objectives across the TCPED framework. The second task focuses on the requirements defined by STANAG 4607 GMTI, STANAG 4609 EG 0903.0 VMTI, and NATO Study 4676 NITS and the ability to identify object/target information, provide metadata, and rapidly retrieve "bookmarked" portions of a GMTI, video, or tracking stream. OWS-8 will analyze and document to level of support in OGC standards to address these operational requirements. Specific items to be performed in OWS-8 include:

- Investigate, evaluate and recommend areas of harmonization between OGC Sensor Web Enablement, OGC GML-based standards, and OGC Tracking and Notification Service, to support STANAG 4607 Ground Moving Target Indication Format (GMTIF), Edition 3; STANAG 4609, Edition 3, EG0903.0 Video Moving Target Indicator (VMTI); and NATO Study 4676 NATO ISR Tracking Standard (NITS).
- Document a set of architecture viewpoints showing the use of SWE and other OGC standards to implement the TCPED-based GMTI, VMTI, and ISR Tracking concept of operations. The viewpoints show the application of OGC service and encoding standards along with other standards. Document any gaps and shortfalls found in the architecturally relevant OGC suite of standards where implementations supporting GMTI, VMTI, and/or ISR Tracking would fall short of defined requirements. The OWS-8 ER on this topic could become the basis for an OGC Best Practice.

4.2.2.2 Moving Object Bookmark

A key VMTI CONOPS objective is to support the generation of tracks near the surface of the earth including terrestrial, littoral, and deep water areas, stationary rotators, and targets flying at low speeds close to the surface of the earth. GMTI and VMTI specifically provide moving and/or mobile object *detections* based on radar and video data, respectively; while NITS provides a mechanism for sharing and storing robust tracking data generated by those detection data. OWS-8 will identify a method for rapid retrieval of specific segments of GMTI, video, or tracking streams, based on a concept of bookmarking of target/track information.

- Document an information model and associated encoding for capturing the track of a moving object based on GMTI and video data, and defined by the NITS. Consideration will be given to how the SWE, GML and GML profiles might be used to build tracks of

multiple snapshots. Consider Motion Imagery which may contain multiple tracks or bookmarks.
- Implement the Moving Object Bookmark in a services framework using SWE and other OGC standards. The design for the implementation will be the TCPED-based VMTI Concept of Operations defined in OWS-8. Priority in the implementation will be given to the user needs and work back to source. Not all of the TCPED functions are anticipated to be implemented in OWS-8.
- Evaluate and demonstrate use of GeoSMS for event notification to desktop and handheld device. The GeoSMS should be considered for applicability in delivery of results to handheld devices.
- Deploy a prototyped OGC solution for GMTI/VMTI/ISR Tracking supporting the bookmarking of moving objects concept as derived from motion imagery.
- Consider any required modifications or enhancements to the OGC SWE 2.0 suite of standards in order to support the defined NATO standards for GMTI, VMTI, and ISR Tracking, and develop Change Requests as required.

4.2.2.3 WCS 2.0 Coverage Profiles, Processing, and Compliance

Additional emphasis in this thread is on fusion of Earth Observation coverages, with focus on the following tasks related to the recently adopted WCS 2.0 standard:

- WCS 2.0 EO-AP Definition and Implementation. Develop implementation experience with the draft WCS 2.0 Earth Observation Application Profile (EO-AP).
- WCS 2.0 EO-AP Compliance Testing. Develop Compliance Test suite for the WCS 2.0 AP including completing the ATS and developing the ETS and Reference Implementation.
- Processing of EO Coverages: WCPS and WPS. Develop WCPS for advanced access to Earth Observation Coverages. Develop WPS for Earth Observation data analysis of multiple coverages and other data.

4.2.3 Observation Fusion Requirements

4.2.3.1 Advancement of Moving Target Indicator Standards

References

- Motion Imagery Standards Board Engineering Guideline 903.0:
  Video Moving Target Indicator Local Data Set (VMTI LDS)
  http://www.gwg.nga.mil/misb/docs/eg/EG0903.pdf
- Motion Imagery Standards Board Engineering Guideline 903.2 Annex C:
  Video Moving Target Indicator CON-OPS (VMTI CON-OPS)
  http://www.gwg.nga.mil/misb/docs/eg/EG0903.pdf
- STANAG 4607: NATO Standardisation Agreement (STANAG) Ground Moving Target Indicator Format (GMTIF), Edition 3
  http://www.nato.int/docu/stanag/4607/4607_home.htm
- NATO Study 4676: NATO ISR Tracking Standard (NITS), URL TBD

- Sensor Web Enablement standards
http://www.opengeospatial.org/ogc/markets-technologies/swe
- Geography Markup Language (GML)
http://www.opengeospatial.org/standards/gml
- GML Profile: OGC MovingObjectSnapshot OGC doc #10-034r3
http://portal.opengeospatial.org/files/?artifact_id=39874
- OGC Open GeoSMS Specification OGC doc #09-142r4
http://portal.opengeospatial.org/files/?artifact_id=39451&version=1

4.2.3.1.1 Implementing VMTI/TCPED with OGC Standards

The Video Moving Target Indicator (VMTI) Concept of Operations provides a view of VMTI for a Tasking, Collection, Processing, Exploitation, Dissemination (TCPED) environment. NATO ISR Tracking Standard (NITS) extends this framework into the MULTI-INT fusion realm, envisioning the interaction of moving object tracks derived from motion imagery with other sources of information for sensor and decision fusion and situational awareness.

The OGC SWE standards have been previously placed in a TCPED framework. This work item focuses on two specific areas of requirements. The first is identifying and documenting OGC standards and/or other relevant open standards to meet the GMTI, VMTI, and ISR Tracking objectives across the TCPED framework. The second task focuses on the requirements defined by GMTI (STANAG 4607), VMTI (STANAG 4609 EG 0903.0), and ISR Tracking (NATO Study 4676), and the ability to identify target information, provide metadata, and rapidly retrieve "bookmarked" portions of GMTI, video, or tracking streams. OWS-8 will analyze and document the level of support in OGC standards to address these operational requirements. Specific items to be performed in OWS-8 include:

- Investigate, evaluate and recommend areas of harmonization between OGC Sensor Web Enablement, OGC GML-based standards, and OGC Tracking and Notification Service, to support STANAG 4607 GMTIF, STANAG 4609 EG0903.0 VMTI, and NATO ISR Tracking Standard (NITS).
- Document a set of architecture viewpoints showing the use of SWE and other OGC standards to implement the TCPED-based VMTI concept of operations. The viewpoints show the application of OGC service and encoding standards along with other standards. Document any gaps and shortfalls found in the architecturally relevant OGC suite of standards where implementations supporting GMTI, VMTI, and/or ISR Tracking would fall short of defined requirements.

4.2.3.1.2 Moving Object Bookmark

A key VMTI CONOPS objective is to support the generation of tracks of moving objects near the surface of the earth including terrestrial, littoral, and deep water areas, stationary rotators, and targets flying at low speeds close to the surface of the earth. VMTI specifically provides moving object detections, based on video data, and along with other sources supports the generation of robust tracking data. OWS-8 will identify a method for rapid retrieval of specific segments of GMTI, video, and tracking streams, based on a concept of bookmarking of target/track information.

- Document an information model and associated encoding for capturing the track of a moving object based on GMTI and/or video data and defined by STANAG 4607, STANAG 4609 EG0903.0, and NATO Study 4676, respectively. Consideration will be given to how the SWE, GML and GML profiles might be used to build tracks of multiple snapshots. Consider Motion Imagery which may produce multiple tracks or bookmarks.

- Implement the Moving Object Bookmark concept in a services framework using SWE and other OGC standards. The implementation design will be the TCPED-based VMTI Concept of Operations described in OWS-8. Priority in the implementation will be given to the user needs and work back to source. Not all of the TCPED functions are anticipated to be implemented in OWS-8.
- Evaluate and demonstrate use of GeoSMS for event notification to desktop and handheld device. The GeoSMS should be considered for applicability in delivery of results to handheld devices.
- Deploy a prototyped OGC solution for GMTI, VMTI, and ISR Tracking supporting the bookmarking of moving objects concept as derived from radar and motion imagery.
- Consider any required modifications or enhancements to the OGC SWE 2.0 suite of standards in order to support STANAGs 4607 and 4609, and NATO Study 4676, and develop Change Requests to OGC specifications as required.

4.2.3.2 WCS 2.0 Earth Observation - Application Profile (EO-AP)

OGC recently approved the OGC Web Coverage Service (WCS) Interface Standard, Version 2.0. The WCS 2.0 has several significant enhancements over previous versions. WCS 2.0 is harmonized with the Geography Markup Language (GML) coverage model, leading to increased interoperability across OGC standards. Further, WCS 2.0 is highly modular and follows the OGC's new Modular Specification Policy, which describes a design pattern that makes standards easier to understand and implement.

The WCS 2.0 Overview anticipates development of an Earth Observation Application Profile (WCS 2.0 EO-AP). Since the release of the WCS 2.0 suite of documents, a WCS 2.0 EO-AP has been drafted in ESA's HMA project. The EO-AP builds on previous work in WCS 1.0. The EO-AP draft includes either NetCDF , GeoTiff or JPEG2000 as a return format. The EO-AP draft will be further developed in OWS-8 including testing with multiple datasets and will be coordinated with development of a Compliance Test Suite.

4.2.3.2.1 OWS-8 Observation Fusion Thread will develop the WCS 2.0 Earth Observation Application Profile (EO-AP) and document it as an OWS-8 Engineering Report.

4.2.3.2.2 WCS 2.0 EO-AP shall include data models for:

- 2-D Coverage with latitude and longitude axes, which can represent, for example, a hyperspectral satellite scene.
- the subset of a 2-D satellite scene (either radar or multispectral)
- a time series of co-registered 2-D satellite scenes
- Stitched Mosaic as a 2-D horizontal coverage which can refer to several co-referenced non-overlapping Datasets;
- Dataset Series as a collection of coverages; A Dataset Series can refer to any number of co-referenced Datasets and Stitched Mosaics.

4.2.3.2.3 OWS-8 Observation Fusion thread will design WCS 2.0 ECS-AP for coverages data models that address the following data products:

- MODIS (specific products to be identified.)
- ENVISAT MERIS L3 demonstration products http://earth.eo.esa.int/level3/
- ENVISAT ASAR Wide Swath
- Limb-scanning instruments (e.g. Microwave Limb Sounder) typically produce vertical profiles,
- Narrow-swath instruments (e.g., CALIPSO) produce vertical cross-sections.

4.2.3.2.4 WCS 2.0 EO-AP shall include these operations:

- GetCapabilities,
- DescribeCoverage
- GetCoverage

4.2.3.2.5 OWS-8 Observation Fusion thread will investigate a new request type, DescribeEOCoverageSet for WCS 2.0 EO-AP, which may be needed to address the particular semantics of EO coverages. Priority should be given to determine if such a new operation is needed or if the semantics of an EO coverage can be described in the existing DescribeCoverage

4.2.3.2.6 WCS 2.0 EO-AP shall include WCS 2.0 Extensions for

- Band Subsetting,
- Scaling & Interpolation
- EPSG CRS

4.2.3.2.7 WCS 2.0 EO-AP shall include the following format encodings

- GeoTIFF
- NetCDF (including the option for CF-netCDF)
- JPEG2000
- HDF-EOS

4.2.3.2.8 WCS 2.0 EO-AP shall include the following protocol bindings

- GET/KVP
- SOAP

4.2.3.2.9 OWS-8 Observation Fusion thread will design WCS 2.0 ECS-AP to scale to large number of coverages as is typical in the data archives of ESA and NASA. The EO-AP design should consider the issues described in these documents:

- "Interoperability between OGC CS/W and WCS Protocols," NASA SPG ESDS-RFC-014
- "Lessons Learned Regarding WCS Server Design and Implementation," NASA SPG ESDS-RFC-016
- OWS 1.2 image handling requirements, Discussion Paper, OGC Document 04-052

4.2.3.3 WCS 2.0 EO-AP Compliance Test Suite

Validating compliance with an OGC specification means verifying that a software product has implemented the specification correctly by testing the software interface for response and behavior that is defined in the standard. Verifying compliance to the standard is necessary in order to achieve interoperability. The OGC Compliance Test Program is intended to provide the geospatial industry (consumers and vendors) a methodology and tools that certify compliance with OGC standards.

Previous OWS Testbeds made significant progress in developing the suite of compliance tests for the OGC standards, as well as developing an open source TEAM Engine. The TEAM Engine facilitates integration of new testing scripts and makes possible testing online.

OWS-8 will produce compliance tests and a reference implementation for WCS 2.0, in particular for Earth Observation Application Profile.

4.2.3.3.1 OWS-8 Observation Fusion will complete the development of the Abstract Test Suite (ATS) in the WCS 2.0 EO-AP. The ATS will be included in the WCS 2.0 EO-AP Engineering Report.

4.2.3.3.2 OWS-8 Observation Fusion will develop Executable Test Scripts (ETS) for use with the OGC Compliance Testing TEAM Engine. The ETS will test the assertions contained in the WCS 2.0 EO-AP ATS.

4.2.3.3.3 OWS-8 Observation Fusion will develop a Compliance Test Reference Implementation (RI) of the WCS 2.0 EO-AP. The RI shall be developed based upon an implementation provide by the ESA HMA Project. The RI will be open source as are all OGC Compliance Test RIs. The RI shall successfully pass the WCS 2.0 EO-AP ETS.

4.2.3.3.4 OWS-8 Observation Fusion will develop an Engineering Report that summarizes the development of the WCS 2.0 EO-AP test suite.

4.2.3.3.5 Following development in OWS-8, the WCS 2.0 EO-AP Compliance Test Suite services will be tested in a beta test period. The beta testing will be announced to the full OGC membership. The beta test period seeks to satisfy the requirement three implementations must pass the compliance tests before the OGC membership votes on approving compliance test suite. Optimally this beta test period will be conducted concurrently with the OWS-8 Testbed.

4.2.3.4 Processing for EO Coverages.

OWS-8 will develop methods for processing of Earth Observations using the WCPS and WPS standards. The processing will include geospatial algorithms relevant to EO data.

4.2.3.4.1 OWS-8 Observation Fusion will develop an OWS-8 Geoprocessing of Earth Observations ER that documents the results of geoprocessing of EO coverages performed in OWS-8. The ER will include the processing done in OWS-8 with both WCPS and WPS.

The Web Coverage Processing Service (WCPS) is an extension to the WCS. WCPS allows filtering, processing, extraction, and analysis of multi-dimensional raster coverages using a protocol-neutral language to specify the requests. Just like the WCS, coverages accessible through WCPS appear to the user as if they are “contained” in the WCPS server, i.e., data is tightly bound to WCPS.

4.2.3.4.2 OWS-8 Observation Fusion will deploy a WCPS that provides multi-coverage fusion capabilities with different, heterogeneous raster types, for example 1-D sensor time series, 2-D hyperspectral remote sensing data and bathymetry/elevation data, 3-D EO time series, 4-D climate data.

4.2.3.4.3 OWS-8 Observation Fusion will develop sufficiently complex WCPS queries, taken from real-life examples, to make them convincing to domain experts.

4.2.3.4.4 The OWS-8 WCPS shall return coverages encoded following the GML Application Schema for Coverages (09-164r1) in combination with the coverage formats like GeoTIFF, NetCDF, and JPEG2000.

4.2.3.4.5 OWS-8 Observation Fusion will develop concepts for non-raster coverages. The result should be recommendations for non-gridded coverages. The CF-netCDF data types should be considered in this analysis.

The OGC Web Processing Service (WPS) has been previously applied to Earth Observation scenarios, e.g., OWS-5 Testbed. The OWS-5 EO WPS ER makes a distinction between: 1) processing that can be done as part of the coverage access, e.g., sub-selection, versus 2) processing that may include several different data types and services. This distinction may be relevant to determining the differing emphasis of WCPS and WPS-EO in OWS-8.

Currently, there is an emphasis in OGC to define a limited set of WPS profiles that aim to converge the number of WPS profiles to a minimum set. OWS-8 will consider if a WPS – Earth Observation Profile should be one part of the minimum set of WPS Profiles.

4.2.3.4.6 OWS-8 Observation Fusion will deploy a WPS that provides processing algorithms relevant to Earth Observations, i.e., WPS-EO

4.2.3.4.7 The OWS-8 WPS-EO shall provide data analysis algorithms that processes
- Multiple coverages from one or more WCSs
- Coverage from a WCS along with other data, e.g. from a WFS.

4.2.3.4.8 The OWS-8 WPS-EO shall include implementation of the following data handlers:
- GeoTIFF
- NetCDF (including the option for CF-netCDF)
- JPEG2000
- HDF-EOS
- GML 3 - limited to GML Simple Features profile and GML AP - Coverages

4.2.3.4.9 OWS-8 Observation Fusion will develop concepts for matching of data coming from different services that support WPS processing. For example consider approaches to describe scientific meaning of data for automatic data match.

4.2.3.4.10 OWS-8 Observation Fusion will develop an initial WPS-EO Profile to be documented in the OWS-8 Geoprocessing of Earth Observations ER (or in a separate ER – currently unfunded)

4.2.4 Observation Fusion Deliverables

Each thread requires two types of deliverables:

- **Documents: Engineering Reports (ER), Information Models (IM), Encodings (EN), and Change Requests (CR)**
  These shall be prepared in accordance with OGC published templates as defined on the OGC portal. Engineering Reports shall 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. All documents created in response to this program shall include "OWS-8" in the title, to facilitate later literature searches.

- **Implementations: Services, Clients and Tools**
  Each of these shall 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 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.

Note that certain draft deliverables will be required by the due dates for Key Initial Design and/or the Interim Milestone as shown in the Master Schedule (RFQ Main Body, Section 4.6), for use in cross-thread development. These early deliverables will be designated and handled on a per-thread, per-deliverable basis.

4.2.4.1 Documents Required

The following Engineering Reports and other documents will be developed in the Observation Fusion thread and submitted to the OGC Specification Program at the completion of the OWS-8 Testbed.

Table 4-1. Observation Fusion Engineering Reports (ER), Information Models (IM), Encodings (EN), and Change Requests (CR)

1) OWS-8 Moving Target Indicator and Moving Object Bookmark Implementation with OGC Standards Investigate, evaluate and recommend areas of harmonization between OGC specifications, to support GMTI, VMTI, and ISR Tracking Document architectural viewpoints showing the use of SWE and other OGC standards to implement the TCPED-based VMTI concept of operations. Document an information model and associated encoding for capturing the track of a moving object and bookmarking that track in motion imagery based on tracks as defined by NITS, and video data as defined by MISB EG 0903.0.	ER/EN
2) OWS-8 SWE CRs for NITS and GMTI/VMTI. Develop Change Requests as required to the OGC SWE 2.0 suite of standards in order to support STANAG 4607 GMTIF, STANAG 4609, EG0903.0, and NATO Study 4676 NITS.	CR

3) OWS-8 WCS 2.0 Earth Observation Application Profile (EO-AP)	ER, IM
4) OWS-8 WCS 2.0 EO-AP Compliance Test - Report on developing the test scripts.	ER
5) OWS-8 ETS for WCS 2.0 EO-AP Executable test scripts for WCS 2.0	EN
6) OWS-8 Geoprocessing of Earth Observations (ER) Report on usage and lessons learned with WPS and WCPS extension for WCS 2.0 EO-AP.	ER

4.2.4.2 Implementations Required

Implementations of the following services, tools and clients will be developed in this thread, tested in Technology Integration Experiments (TIEs), and invoked for cross-thread scenarios for OWS-8 demonstration events:

Table 4-2. Observation Fusion Services, Clients and Tools Required

1) SOS server for Motion Imagery. SOS serving motion imagery and moving objects detections. It also responds to requests for "bookmarked" motion imagery.	Service
2) WPS server for Moving Objects Tracks Generation. Inputs motion imagery detections from an SOS and outputs moving object tracks in the encoding format defined in the ER above.	Service
3) Tracking and notification service. The RFQ seeks innovative proposals for how to meet the function of dynamic tracking and notification functions. Service should include a notification mechanism that implements the GeoSMS draft specification. Given the high volume of sensor position updates and the need for rapid notification to users, the specific name for this service will be identified based upon RFQ proposals.	Service
4) CSW for SWE and Motion Imagery Bookmarks. CSW ebRIM with support for describing, storing and querying SWE services and motion imagery bookmarks. ***Note: The catalog service is a possible cross-thread topic with all other threads.***	Service
5) Observation Fusion Client. Client component that can exercise all the motion-imagery related services above.	Client
6) Moving Object Mobile Client. The focus for this client is on receiving GeoSMS notifications. The ability to exercise moving object bookmarks is optional.	Client
7) Client for WCS access and geoprocessing. Client for WCS EO-AP, WCPS and WPS.	Client
8) WCS 2.0 EO-AP Reference Implementation. Server hosting EO data, to be furnished by EOX in the context of HMA-FO Project Task 3.	Service
9) WCPS for EO-AP. Server hosting EO data: WCPS Extension on WCS 2.0 EO-AP.	Service
10) WPS for EO data analysis. WPS-EO component composed of Server and Client; with EO Algorithms.	Service

4.2.5 Observation Fusion Enterprise Viewpoint

4.2.5.1 Community and Objectives

The Sensor Web represents a meta-platform that integrates arbitrary sensors and sensor networks; each maintained and operated by individual institutions. This reflects the existing legal, organizational and technical situation. Sensors and sensor systems are operated by various organizations with varying access constraints, security, and data quality and performance requirements. The architectural design of the Sensor Web allows the integration of individual sensors as much as the integration of complete sensor systems without the need of fundamental changes to the constituent systems.

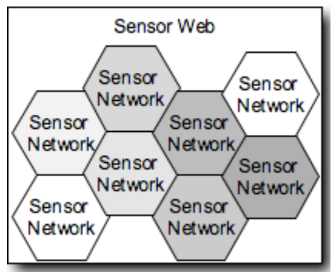


Figure 4-3. Sensor Web: Aggregation of Sensor Networks

Once connected to the Sensor Web, data sets may get used multiple times in applications never intended by the original system setup. Traffic sensors that have been deployed initially to avoid jams by dynamic traffic control might get used to calculate the carbon dioxide ratios of highway sections in another application. Satellites with different sensors on board might get used in a variety of application domains that were not primarily targeted, simply due to interoperable interfaces that allow users to task the satellite based on distinct requirements.

The Sensor Web is a revolutionary concept towards achieving a collaborative, coherent, consistent, and consolidated sensor data collection, fusion and distribution system. It can be viewed as a new breed of Internet for monitoring spatio-temporal phenomena appearing in the physical environment in real time. Any kind of sensor, from a thermometer located at a fixed position to a complex hyper-spectral sensor on board of an earth-orbiting satellite, will be made available on a global level in the near future.

The SWE framework has been designed to enable solutions that meet the following desires:

- Discovery of sensors, observations, and processes
- Determination of a sensor's capabilities and an observation's reliability
- Access to parameters and processes that allow on-demand processing of observations
- Retrieval of real-time or time-series observations in standard encodings –
- Tasking of sensors and simulators to acquire observations of interest
- Subscription to and publishing of alerts based on sensor or simulation observations

4.2.5.2 Sensor Fusion

The objectives of standards-based fusion were presented in Sections 2.1 and 4.1. Advancing standards-based Sensor Fusion is an objective of the Observation Fusion thread.

Sensor Fusion considers sensor measurements of various observable properties to well characterized observations including uncertainties. Fusion processes involve merging of multiple sensor measurements of the same phenomena (i.e. events of feature of interest) into a combined observation; and analysis of the measurement signature.

Sensor fusion concerns the acquisition and exploitation of multiple measurements for the purpose of:

- Obtaining a higher-level or more accurate measurement
- Recognizing objects and events of interest
- Determining properties of particular objects or events

Sensor fusion involves how measurements are made available to fusion processes and how the fusion processes make use of the observations to create semantically higher order entities, e.g., geospatial features.

The relationships between sensor observations, recognized objects, and the fusion processes are illustrated in Figure 4-3 while each part is discussed in more detail below.

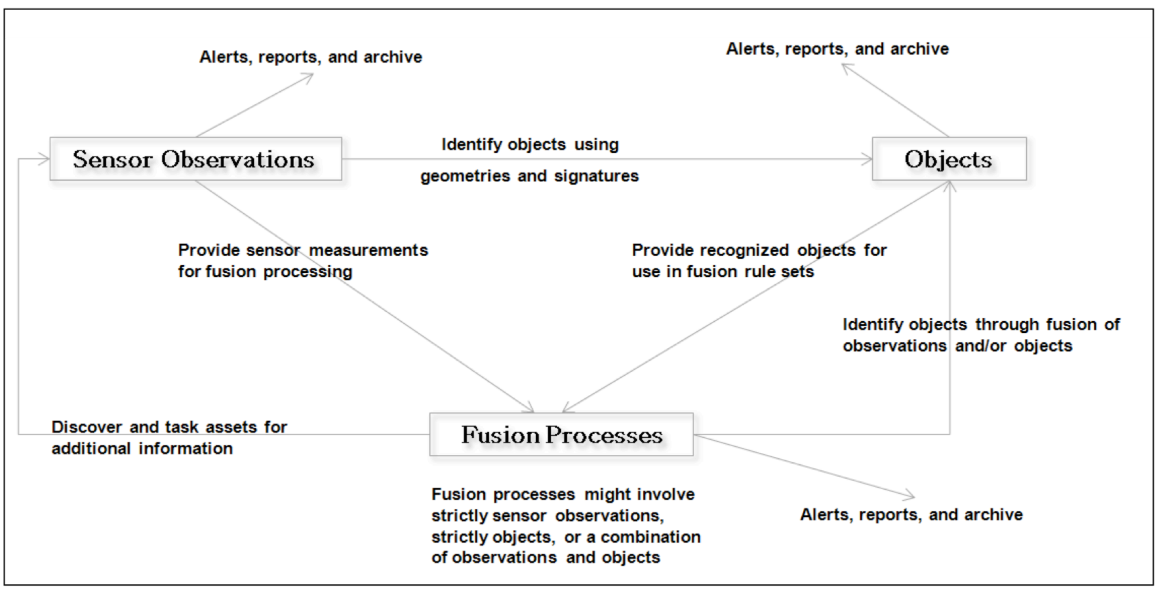


Figure 4-4. Sensor Fusion processes

Sensors Observations. Much information suitable for fusion begins with or is derived from observations by sensors or humans. This is particularly true for information that is highly dynamic in nature and of a timely nature. These observations, either raw or processed, can serve as input into fusion processes or they may be used to identify recognizable objects or features that are then treated as input into a fusion process.

Objects for Fusion. Objects that are suitable for fusion and for enhancing situation awareness can include those that are fairly persistent and exist in a geospatial feature database (e.g. streets, buildings, etc.), as well as those that are highly dynamic and sensed in real time by sensors and human observers. Examples of highly dynamic features include explosions, gunshots, the passing of a vehicle, the movement of persons or objects of interest, the opening of a door, or the placement of an Improvised Explosive Device (IED), just to mention a few.

Fusion Processes. Fusion processes might take as input sensor observations, recognized objects/features, or a combination of both. The results of the fusion process might themselves include identified features of interests and might again be streamed in real-time, published as alerts or reports, or distributed to archives. Additionally the fusion process might result in a need to discover and task additional sensor assets that can provide information needed to refine or provide additional situation awareness.

4.2.5.3 NATO ISR Tracking Standard (NITS) Operational Concept

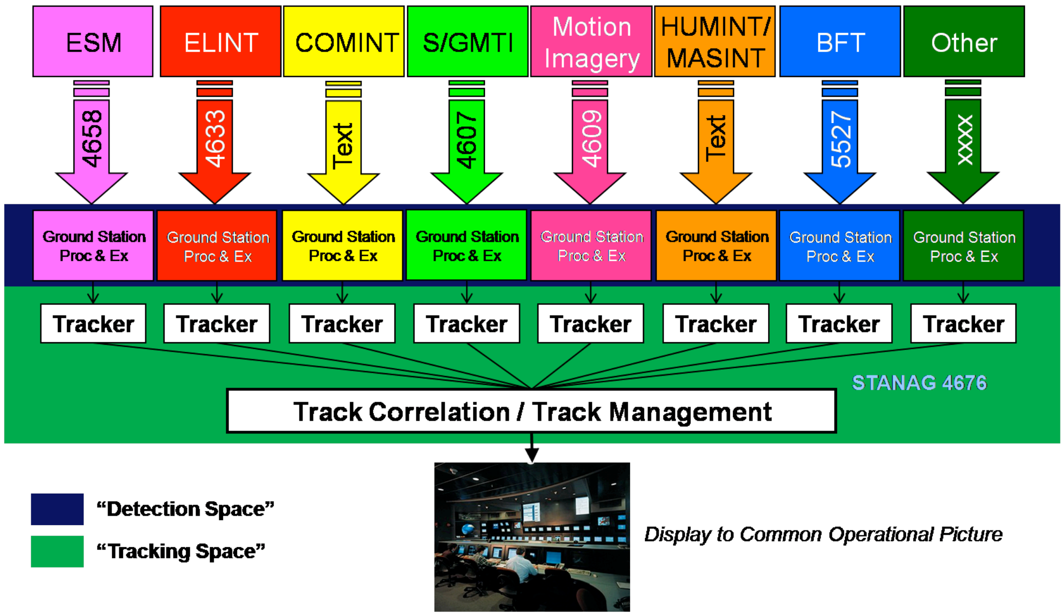
The purpose of the NITS is to allow data to be passed between entities producing and using track data; including all ISR (Imagery, Surveillance, and Reconnaissance) disciplines. Tracking must encompass all surface, sub-surface, air, ground, and space tracks and the standard must be flexible enough to allow for all of those situations. To that end, STANAG 4676 must ensure the standardization of data for tracking movement/motion in an area of interest or battlefield, see Figure 4-5.

Tracks can be "raw" from sensor, or processed by a ground station node or tracker. The primary uses for tracking that STANAG 4676 is addressing are:

1. Time Sensitive Targeting (TST) applications
2. Back tracking / Forensics
3. Prediction (where the track be given current metrics)
4. Intelligence Preparation of the Battlefield (IPB)

NITS intends to facilitate data correlation and fusion, with an eye towards future developments in fusion. The objective is to provide an efficient standard for data exchanges between platforms, sensors, and systems to capture active and archived tracks from single sensors as well as those derived from trackers utilizing multi-INT data sources.

Case 1 – Track Correlation



Case 2 – Track Fusion

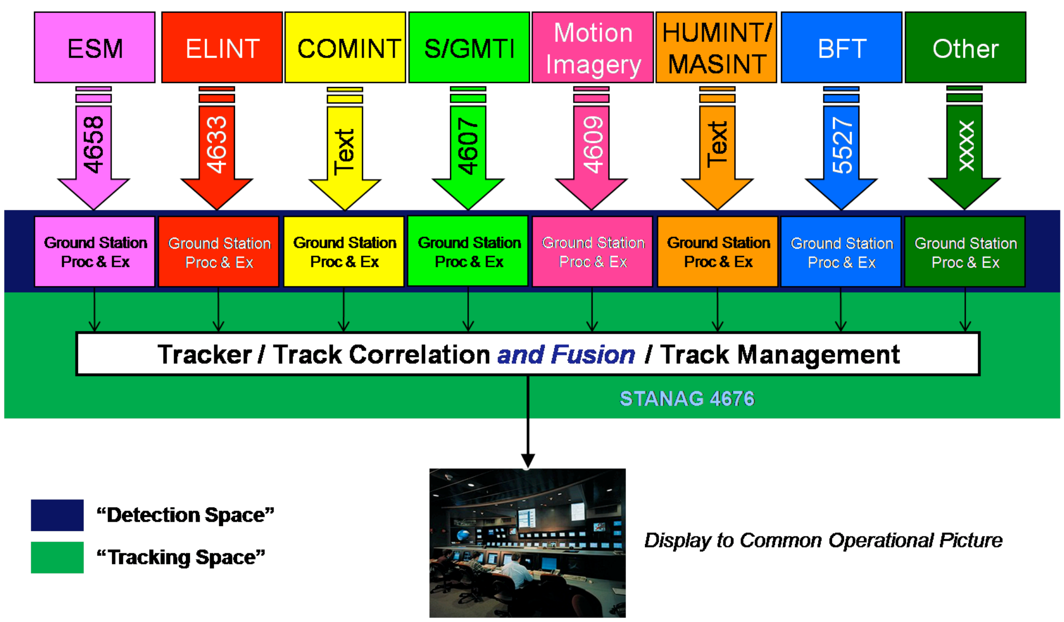


Figure 4-5: NITS Tracking Architecture

4.2.5.4 VMTI Concept of Operations

Reference: VMTI Concept of Operations, MISB, Annex C to MISB EG 0903.2, 21 July 2010

The VMTI conceptual workflow (Figure 4-3) is a notional representation of the processing that a VMTI collect must go through to produce valuable intelligence source. This is an aid to the discussion of the VMTI data model and to promote an understanding of where and how the data model is populated. As we go through the workflow, the data model will be discussed in terms of the classes defined in the VMTI object model.

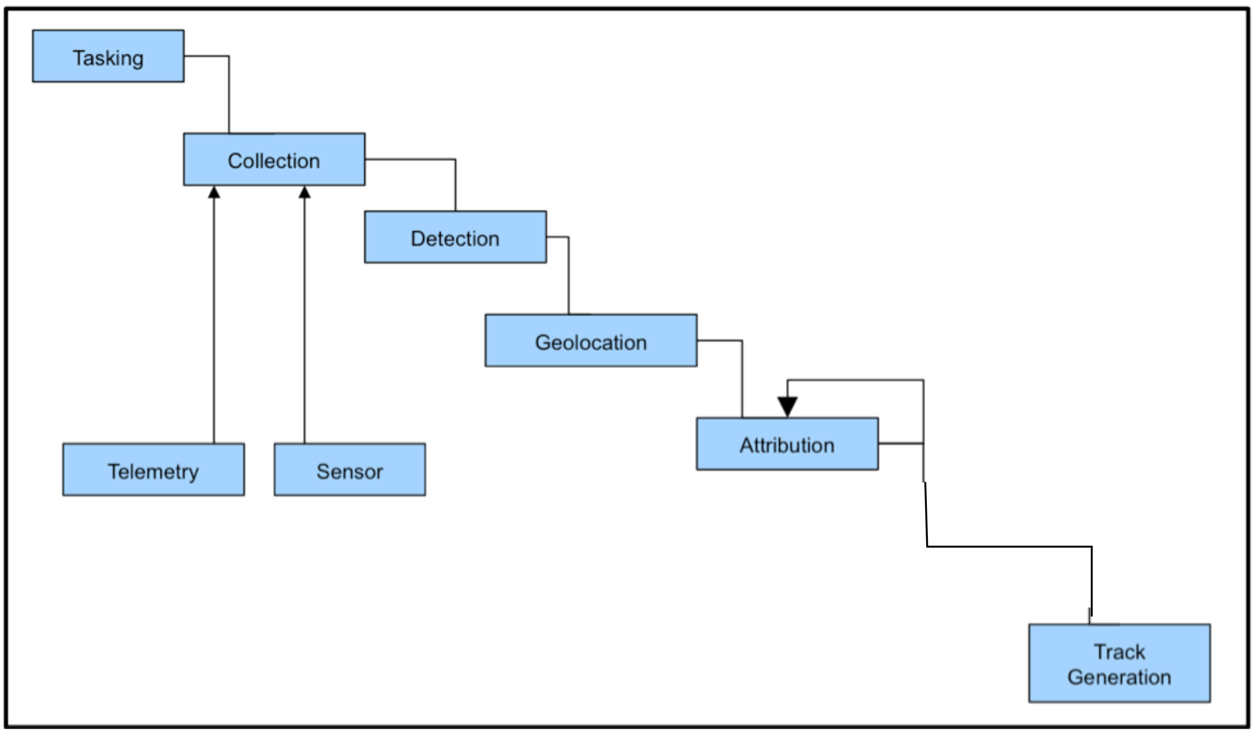


Figure 4-6: VMTI Conceptual Workflow

Tasking

Tasking is the act of planning the collect and allocation of resources and schedule for the mission. The Tasking task will result in the population of mission, sensor, and platform metadata related to the configuration and identification of the collect.

Collection

The Collection task is the act of collecting the motion imagery and associated telemetry. This task will result in the population of observation and motion metadata.

In terms of the SWE framework, Collection results in Sensor Observations. The following tasks create Sensor Objects, which may be derived directly from Sensor Observations, or indirectly derived through Sensor Fusion of Sensor Objects and/or Observations.

Detection

Once data has been collected, it is time to examine the motion imagery for any moving objects. This Detection task populates the VMTI metadata associated with initial detects.

Geolocation

With the exception of the sensor location, (which is provided by the GPS/IMU), all VMTI location metadata must be calculated. Input data to these calculations include the sensor location, sensor orientation, and frame parameters. Often a digital elevation model of the area being collected is required as well.

Attribution

At this point we have identified candidate moving objects and their geo-locations. The Attribution task puts some meat on those bones in the form of characteristics that help identify and classify the moving object.

Attribution is a task that is likely to be repeated often in the course of an actual workflow. As the attribution of the detections gets more detailed, it becomes easier to filter out the detections of low interest. High interest detections could then cycle through another round of attribution and filtering.

Track Generation

Track Generation is the end of the line for the VMTI data. In this task, the VMTI data is brought together with other source to generate robust tracking data. Output from this task will be targeting and tracking data in formats such as STANAG 4676, which is under development.

The focus of this testbed is on the Track Generation stage, where detections have been associated with real world objects, and transformed into tracks of moving objects to be encoded in data formats such as STANAG 4676.

4.2.5.5 Observation Fusion - Moving Objects Scenario

Observation Fusion in OWS-8 focuses on integrating NITS and VMTI/GMTI into the SWE architecture. As sensor information such as motion imagery moves from observations to the value-added products of fusion processes, it has wider applicability to a range of users, and hence, interoperability becomes crucial for ready integration into a wide array of situational awareness systems.

In this testbed we will employ a scenario that calls for the tracking and identification of a moving object as it travels along a road and stops at various locations. Participants will be provided with motion imagery that shows the moving object's path. From this, participants will generate detections – partial VMTI metadata for the motion imagery encoding locations of objects – and tracks – NITS/VMTI metadata encoding the moving object's path.

Participants will also develop a method for "bookmarking" segments of the motion imagery that interface between the imagery and the moving object detections and tracks.

4.2.5.6 Observation Fusion-Motion Enterprise Use Cases

4.2.5.6.1 Moving Object Tracking

The Enterprise Viewpoint use case presented below focuses on creating moving object tracks and saving them as NITS metadata associated with the motion imagery.

<table>
<tr><td colspan="2">Use Case Identifier: OF #1</td><td colspan="2">Use Case Name: Moving Object Tracking</td></tr>
<tr><td colspan="3">Use Case Domain: OWS-8 OF</td><td>Status: Draft 2010-11-12</td></tr>
<tr><td colspan="4">Use Case Description: Motion imagery is used to detect objects in a scene. NITS data is created that generates tracks of moving objects from these detections. For the purposes of this Testbed, the detection creation may be done through an automated process, or manually.</td></tr>
<tr><td colspan="2">Actors (Initiators):

Imagery Analyst reviewing motion imagery with detections</td><td colspan="2">Actors (Receivers):

Same as initiator</td></tr>
<tr><td colspan="2">Pre-Conditions:

Motion imagery of AOI has been previously acquired and is available on-line via SOS.</td><td colspan="2">Post-Conditions:

VMTI metadata and NITS reports are created.</td></tr>
<tr><td colspan="4">System Components:

1) SOS for Motion Imagery from a camera on a moving ground vehicle.

3) WPS server for track detection algorithm

5) Sensor tracking and notification service

6) Fusion Client in ground vehicle</td></tr>
<tr><td colspan="4">Basic Course of Action:

1. Imagery Analyst accesses SOS with relevant motion imagery (MI).
2. Crew reviews MI in Fusion Client, identifying one or more object detections
3. Crew initiates track creation by the WPS using Fusion Client.
4. Fusion Client saves NITS Tracks to SOS associated with source VMTI metadata detections.
5. Step 4 sets off a notification that triggers use case OF #2.</td></tr>
</table>

4.2.5.6.2 Bookmarking Moving Objects in Motion Imagery

The use case describes a scenario for requesting segments of video using a bookmark. The client uses the bookmark to get quick, efficient access to small portions of the video along with the moving objects track(s).

<table>
<tr><td>Use Case Identifier: OF #2</td><td colspan="2">Use Case Name: Bookmarking Moving Objects</td></tr>
<tr><td colspan="2">Use Case Domain: OWS-8 OF</td><td>Status: Draft 2010-11-12</td></tr>
<tr><td colspan="3">Use Case Description: Imagery Analyst reviews motion imagery with moving object tracks and bookmarks various segments for review by colleagues.</td></tr>
<tr><td>Actors (Initiators):

Imagery Analyst</td><td colspan="2">Actors (Receivers):

Same as initiator</td></tr>
<tr><td>Pre-Conditions:

Motion imagery of AOI has been previously acquired and is available on-line via SOS.

VMTI metadata exists with the motion imagery and contains object detections.

NITS data exists in an SOS containing moving objects tracks association with above data.</td><td colspan="2">Post-Conditions:

Bookmarks created and stored in a catalog.</td></tr>
<tr><td colspan="3">System Components:

1) SOS for Motion Imagery with VMTI metadata and NITS data.

2) CSW for storing bookmarks.

3) Observation Fusion Client on ground.</td></tr>
<tr><td colspan="3">Basic Course of Action:

1. Imagery Analyst accesses motion imagery (MI) and NITS tracks in Fusion Client and reviews key parts of the video.
2. Imagery Analyst uses the Fusion Client to demarcate segments of interest in the video.
3. Imagery Analyst initiates a “save” action, causing the Fusion Client to generate “bookmarks” for the key parts of the video identified in Step 2.
4. Fusion Client allows Imagery Analyst to save bookmarks to disk, or to CSW.</td></tr>
</table>

4.2.5.7 Observation Fusion-Coverages Subthread: Earth Observations

Understanding the Earth system – its weather, climate, oceans, atmosphere, water, land, geodynamics, natural resources, ecosystems, and natural and human-induced hazards – is crucial to enhancing human health, safety and welfare, alleviating human suffering including poverty, protecting the global environment, reducing disaster losses, and achieving sustainable development.

Observations of the Earth system constitute critical input for advancing this understanding. Earth observation agencies have accumulated large archives through multiple years of satellite remote sensing observations. Two examples underline the challenge in making EO data accessible to the widest audience:

As part of NASA's Earth Observing System (EOS), MODIS sensors have provided daily global coverage for the past 10 years. EOS is observing the key physical variables needed to advance understanding of the entire Earth system and develop a deeper comprehension of the components of that system and the interactions among the components. EOS is providing systematic, continuous observations from low Earth orbit for a minimum of 15 years.

ESA's Envisat – launched in 2002 - is the largest Earth Observation spacecraft ever built. It carries ten sophisticated optical and radar instruments to provide continuous observation and monitoring of the Earth's land, atmosphere, oceans and ice caps. Envisat data collectively provide a wealth of information on the workings of the Earth system, including insights into factors contributing to climate change.

4.2.5.8 ESA Heterogeneous Missions Accessibility (HMA) Project.

Reference: http://wiki.services.eoportal.org

ESA is conducting a Heterogeneous Missions Accessibility (HMA) Project. HMA is a collaborative project among the European and Canadian Space Agencies and lead by ESA, with the objective to guarantee a seamless and harmonised access to heterogeneous earth observation (EO) datasets from multiple mission ground segments, including national missions and ESA mission.

The goal of HMA is to standardise the ground segment interfaces of the satellite missions for easier access to earth observation (EO) data. HMA has defined the discovery, catalogue ordering feasibility analysis and identity management interface standards relying on existing standards, if available, and the direct collaboration among the space agencies. HMA is using OGC processes to discuss the proposed standards.

4.2.5.9 NASA Earth Science Technology Office

Reference: http://esto.nasa.gov/

NASA's Earth Science Technology Office (ESTO) demonstrates and provides technologies that can be reliably and confidently applied to a broad range of science measurements and missions as well as facilitate practical applications that benefit society at large. As the lead technology office within the Earth Science division of the NASA Science Mission Directorate, ESTO is focused on the technological challenges inherent in space-based investigations of our planet and its dynamic, interrelated systems.

ESTO developments in advanced information systems are used to process, archive, access, visualize, and communicate science data. Advanced computing and communications concepts that permit the transmission and management of terabytes of data are essential to the ESTO vision of a unified observational network. Information provided to a nationwide community of users will result in significant leaps of knowledge of Earth science dynamics that benefit the global community.

4.2.5.10 Making EO data accessible as Coverages

Traditionally access to Earth Observation data from satellite archives tends to be defined by the way the way in which the data was acquired by the sensor or is stored in the archive. NASA EOS archives for example provide access to "data granules" as the minimum size for an order, which may cover a larger or smaller geographic area than desired. An order involves an asynchronous process of preparing an order with subsequent delivery at a later time. Neither of these concepts – granules or orders – fit the expectation of users of today's web services. After receiving the data, it must be transformed to the same format, map projection, spatial and temporal coverage, spatial and temporal resolution as the other datasets being used in the analysis.

Using Coverages as the method for providing access allows for the Earth Observations to be access from a users point of view considering the data is to be viewed in a geospatial perspective including other geospatial information. The Web Coverage Service provides an access protocol that defined using geospatial concepts and not archive concepts. The WCS work in OWS-8 aims to continue the Coverage perspective of Earth Observations.

Earth Observation coverages as available from archives can never meet all of the users needs. Users need to have transformations of the data specific to their applications. The OGC Web Processing Service provides for a loosely-coupled, distributed services approach to providing the user with the processing needed to received derived coverages that meet their application needs.

4.2.6 Observation Fusion Information Viewpoint

The information viewpoint is concerned with the semantics of information and information processing. Thus, it discusses a sensor in regard to the semantics behind a sensor or sensor system abstracted from the physical. This viewpoint also describes the observations of a sensor and the metadata about those observations that are relevant to the Testbed requirements. Observation metadata is a primary focus of the Testbed – particularly moving target indictors in motion imagery. To better understand how this type of information fits within the OGC standards framework, it is necessary to describe the SWE information standards as well.

A sensor is a source that produces a value within a well-defined value space of an observed property, which may represent a physical, biological or chemical environmental phenomenon. Sensors and sensor systems as well as simulation models fulfill this definition. If the semantics did not differentiate between produced data based on a physical stimulus or any other data, the limit between model and sensor disappears.

In addition to the observation result, information about the observation procedure, spatial-temporal context, and organizational characteristics have to be provided. Such information is considered to be meta-information for the purpose of interpretation and further processing of the observation results.

4.2.6.1 Sensor Model Language (SensorML)

References:

- *Sensor Model Language (SensorML) Implementation Specification, OGC document 07-000, http://www.opengeospatial.org/standards/sensorml*
- *OWS-6 SensorML Profile for Discovery ER, OGC document 09-033, http://www.opengeospatial.org/standards/sensorml*

SensorML defines models and XML Schema for describing any process, including measurement by a sensor system, as well as post-measurement processing.

Within SensorML, everything including detectors, actuators, filters, and operators are modeled as processes. The type of those processes is either physical or non-physical. The former are called *ProcessModels*, the latter *Components*. Physical processes define hardware assets where information regarding location or interface matters, non-physical processes define merely mathematical operations. The composite pattern allows the composition of complex physical and non-physical processes, called *ProcessChains* and *Systems*.

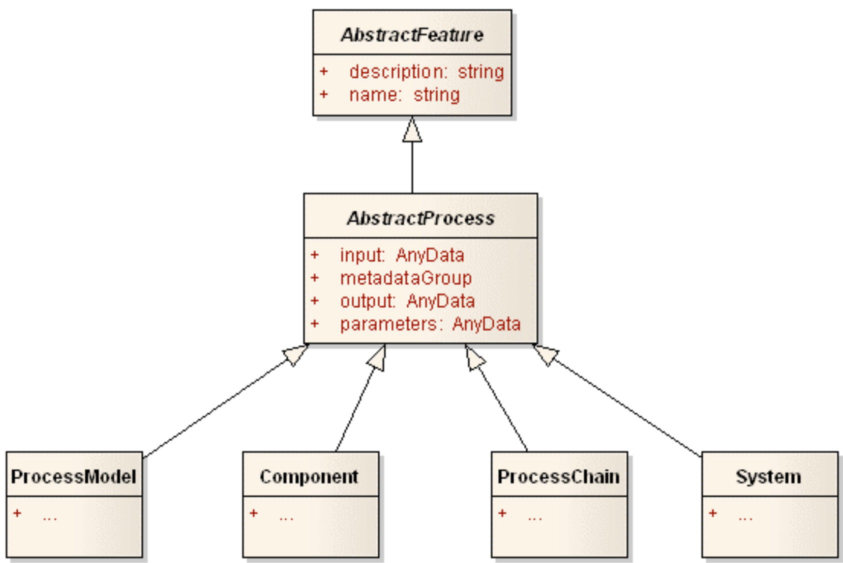


Figure 4-7. SensorML process types

As shown in Figure 4-7, all process types are derived from an *AbstractProcess* that defines the *inputs*, *outputs*, and *parameters* of that process, as well as a collection of metadata useful for discovery and human assistance. The inputs, outputs, and parameters are all defined using SWE Common data types. Process metadata includes identifiers, classifiers, constraints (time, legal, and security), capabilities, characteristics, contacts, and references, in addition to inputs, outputs, parameters, and system location. Further on, it allows modeling the life span of a specific process by defining its history in the form of an event list (e.g. recalibration, adjustments, events, etc.).

The individual processes, as well as data sources (processes with no inputs), can be linked within a *ProcessChain* such that one can describe either the process by which an observation was derived (i.e. its lineage) or a process by which additional information can be derived from an existing observation. The general idea behind this concept is that one can re-use ProcessChains defined externally as part of the own process chain. Thus, complex chains only have to be defined once and can be re-used when made available online. The definition of links allows the proper lineage of a process chain, i.e. describes the relationships between individual processes of the chain.

System is a physical equivalent of a *ProcessChain.* It allows one to relate one or more processes to the "real world" by allowing one to specify relative locations and data interfaces. A System may include several physical and non-physical processes. In addition to the individual process of a process chain and its relationship to each other in terms of out-input behavior, a System defines the position of each component, i.e. it allows describing one physical asset in relation to another one.

The OWS-6 SensorML Profile for Discovery ER specifies a profile of the SensorML OGC standard to be used by sensor and SWE service discovery services and clients. The profile is not restricted to any specific type of sensor or procedure. It can be used as a generic profile for sensor system descriptions with the purpose of being discoverable. The ER uses an exemplarily home weather station to explain the concept of the profile.

A public forum for SensorML is actively maintained and available at http://lists.opengeospatial.org/mailman/listinfo/sensorml.

In OWS-8 SensorML is expected to be used to model characteristics of the process by which motion imagery is captured.

4.2.6.2 Observations and Measurements (O&M)

References:

- *Observations and Measurements - Part 1 - Observation schema, OGC Document 07-022r1*, *http://www.opengeospatial.org/standards/om*
- *Observations and Measurements - Part 2 - Sampling Features, OGC Document 07-002r3*, *http://www.opengeospatial.org/standards/om*

To reflect the general difference between the observation itself, i.e. the act of producing a value for a property of a feature, and the sampled feature itself, Observations and Measurements consists of two parts: Part one, *Observation schema* (OGC 07-022), describes a conceptual model and encoding for observations and measurements. This is formalized as an Application Schema, but is applicable across a wide variety of application domains. Part two, *Sampling Features* (OGC 07-002r3), describes a conceptual model and encoding for the feature that has been observed. According to O&M, every observed property belongs to a feature of interest. Though often treated as identical and mostly of little interest to the consumer of the observation data, there is a conceptual difference between the *Sampled Feature* and the *Feature of Interest* of an observation. The difference is described best using some examples:

- In remote sensing campaigns, the sampled feature is a scene or a swath, whereas the feature of interest often defined as a parcel, a region, or any other form of geographically bounded area
- In-situ observation campaigns may obtain the geology of a region at outcrops (sampled features), whereas the feature of interest is the region itself
- Meteorological parameters might get sampled at a station, whereas the feature of interest is, strictly speaking, the world in the vicinity of that station

The term *Measurements* in *Observation & Measurements* reflects the fact that most sensors produce estimates for physical quantities, i.e. for measures. Thus, a measurement is a specialized observation. This is somewhat in contrast to the conventional measurement theory, but inline with discussions in recent publications.

O&M defines an *Observation* as an act of observing a property or phenomenon, with the goal of producing an estimate of the value of the property. The observation is modeled as a Feature within the context of the General Feature Model [ISO 19101, ISO 19109]. An observation feature binds a result to a feature of interest, upon which the observation was made. The observed property is a property of the feature of interest, as illustrated in the following figure.

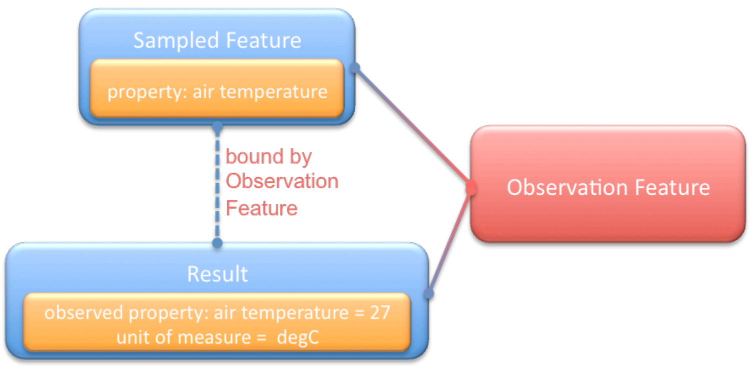


Figure 4-8. Binding of observation results to properties of the sampled feature

An observation uses a procedure to determine the value of the result, which may involve a sensor or observer, analytical procedure, simulation or other numerical process. This procedure would typically be described as a process within SensorML. The observation pattern and feature is primarily useful for capturing metadata associated with the estimation of feature properties, which is important particularly when error in this estimate is of interest.

Through the O&M specification, the SWE framework provides a standard XML-based package for returning observation results. Using a standard package in which to download observations from an SOS alleviates the need to support a wide range of sensor-specific and community-specific data formats. To achieve an even higher level of interoperability, SWE Common shall be used to fill in the result slot of an observation.

In OWS-8 O&M is expected to be used to model motion imagery and perhaps moving object tracks. Particular attention must be paid to the harmonization of OGC standards in this area, such as O&M, and those of other standards communities. There must be clear inter-connection between ISR Tracking, GMTI, VMTI, motion imagery as defined by MISB, and OGC's SWE standards.

4.2.6.3 Motion Imagery

Reference: Motion Imagery Standards Profile (MISP) Version 5.5 3 May 2010, http://www.gwg.nga.mil/misb/docs/eg/EG0903.pdf

The MISP defines Motion Imagery as imagery [a likeness or representation of any natural or man-made feature or related object or activity] utilizing sequential or continuous streams of images that enable observation of the dynamic, (temporal), behavior of objects within the scene. Motion Imagery temporal rates, nominally expressed in frames per second, must be sufficient to characterize the desired dynamic phenomena. Motion Imagery is defined as including metadata and nominally beginning at frame rates of 1 Hz (1 frame per second) or higher within a common field of regard. Full Motion Video (FMV) falls within the context of these standards.

The MISP includes guidance on uncompressed, compressed, and related motion imagery sampling structures; motion imagery time standards, motion imagery metadata standards, interconnections, and common language descriptions of motion imagery system parameters. All of the technology outlined in the MISP document is based on commercially available (or very near term available) systems and components based on defined open standards.

The MISP contains a Motion Imagery Systems Matrix (MISM) for the simple identification of broad categories of Motion Imagery Systems. The intent of the MISM is to give user communities an easy to use, common shorthand reference language to describe the fundamental technical capabilities of DoD/IC/NSG motion imagery systems. The "Motion Imagery Systems Matrix" includes tables of Technical Specifications and related Notes.

The MISM is divided into six bands. Two bands are anticipated to be relevant to OWS-8, but the sponsors are interested in discussion of the applicability of MISM bands to the motion imagery change detection requirements, e.g., can the desired change detection be achieved using Standard Definition Motion Imagery. At a minimum these two MISM bands are to be considered in OWS-8:

- 9720b - "High Definition Motion Imagery"
- 9720d - "Standard Definition Motion Imagery"

Motion imagery is the key source data in this sub-thread. The abillity to create the moving object tracks and bookmarks depends upon a thorough understanding of the imagery information.

4.2.6.4 NITS format

Reference: STANAG 4676: NATO Standardization Agreement (STANAG) NATO ISR Tracking Standard (NITS) For Imagery, Surveillance, & Reconnaissance (ISR) Systems, URL TBD

The objective of the NITS is to provide an efficient standard for data exchanges between platforms, sensors, and systems to capture active and archived tracks from single sensors as well as those derived from trackers utilizing multi-INT data sources.

The data format provides a means for the transmission of multi-source detection data which may include data from single sensors, multiple sensors of a similar type, and sensors from multiple phenomenon or INTs.

At this time, NITS contains only two "report" types for Situational Awareness: A report containing an entire track, and a report that provides a single-track update point. Future capability for targeting/tracking, projections, track request/response, and lineage will be added in future block updates:

All of these report types may be relevant to the Testbed requirements. In this Testbed, participants will attempt to align the NITS information model with that of VMTI LDS (described below) and suggest a harmonization roadmap with SensorML and Observations and Measurements.

4.2.6.5 Video Moving Target Indicator Local Data Set

Reference: "Video Moving Target Indicator Local Data Set," MISB Engineering Guideline, EG 0903.0, 3 September 2009, http://www.gwg.nga.mil/misb/docs/eg/EG0903.pdf.

MISB Standard 0601 UAS Datalink Local Data Set ("*0601*") has become the accepted standard Local Data Set (LDS) within Defense agencies for the transmission of metadata elements within motion imagery streams. *0601* includes numerous individual elements and a few local data subsets but, to date, none of these elements or subsets allows the effective inclusion of VMTI metadata.

The purpose of this Engineering Guideline is to define an LDS for VMTI that complements *0601* metadata. Tag 74 from *0601* has been assigned for the VMTI LDS.

VMTI is information derived from video, but it is meaningful as a product in its own right. Therefore, the VMTI LDS is designed to be transmitted optionally "standalone", *i.e.*, independent of any video essence. The transport stream is permitted to contain just metadata that describes VMTI, in which case it will contain neither video essence nor unrelated engineering metadata elements (*e.g., 0601* Icing Detected).

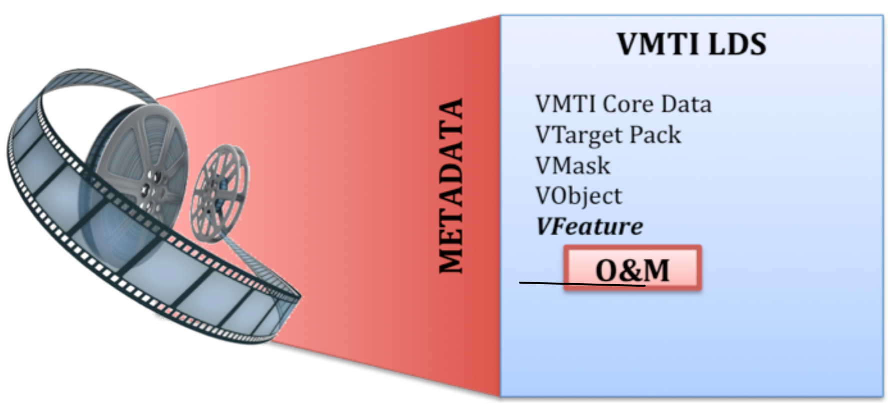


Figure 4-9: High Level Outline of VMTI Metadata

Figure 4-9 lists the major components of VMTI metadata. Most of them have geographic components which may be relevant in this Testbed. In particular, VMask may be used to store object detections, and VFeature is described as being a container for targets or features of targets using Observations and Measurements as an encoding format.

4.2.6.6 Ground Moving Target Indicator

Reference: "NATO Ground Moving Target Indicator Format (GMTIF)," NATO Standardization Agency, STANAG 4607 (Edition 2), 2 August 2007.

The NATO Ground Moving Target Indicator Format (GMTIF) defines a standard for the data content and format for the products of ground moving target indicator radar systems and a recommended mechanism for relaying tasking requests to the radar sensor system.

"Ground MTI" is interpreted to mean targets on the surface of the earth, to include terrestrial, littoral, and deep water areas, stationary rotators, and targets flying at low speeds close to the surface of the earth.

The data format described in this document provides a means for the transmission of Ground Moving Target Indicator (GMTI) detection data. It also offers a format for requesting surveillance service from the sensor and for receiving acknowledgment that the requested surveillance will or will not be performed.

4.2.6.7 GML MovingObjectSnapshot

References:

- *GML Profile: OGC MovingObjectSnapshot OGC doc #10-034r3* *http://portal.opengeospatial.org/files/?artifact_id=39874*

This document defines a GML application schema to encode a snapshot of a moving object including its location, translational velocity and acceleration. This specification addresses the use case of a solid object, such as a car, travelling in a plane local to the object, such as a street. The velocity is an instantaneous vector composed of a scalar speed and a heading relative to North.

This GML profile will not fulfill the requirements of this Testbed, but it may serve as as base information model which can be extended for the work described here.

4.2.6.8 Motion Imagery Bookmarking

Motion imagery bookmarking is a new area of standards development. No directly relevant open standards references have been identified at this time. However, in terms of information requirements, a bookmark needs to include the starting and ending frames of the motion imagery in which the moving objects of interest are found, and the moving objects (or links to the moving objects data) themselves.

4.2.6.9 Observation Fusion-Coverage Subthread: 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. A 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.

4.2.6.10 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 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 are changed in its syntax, nor in its semantics.

4.2.6.11 NetCDF

Reference: CF-netCDF Primer, OGC 10-091r2, "CF-netCDF: Core and Extensions."

CF-netCDF supports encoding of geospatial data – that is, digital geospatial information representing space/time-varying phenomena.

CF-netCDF consists of a set of normative specifications, collectively referred to as "the CF-netCDF suite". These specifications encompass:

- netCDF Core [OGC 10-090]
- netCDF Classic Binary Encoding Extension Standard [OGC 10-092]
- CF-netCDF Conventions Extension Standard [OGC 10-093]

Reference: OGC Network Common Data Form (NetCDF) Core Encoding Standard version 1.0, OGC Document 10-090r2

NetCDF (network Common Data Form) is a data model for array-oriented scientific data. The OGC netCDF encoding supports electronic encoding of geospatial data, specifically digital geospatial information representing space and time-varying phenomena.

Document 10-090r2 is an abstract specification defining the netCDF data model that defines the core set of requirements to which every netCDF encoding must adhere. NetCDF extension specifications can add further functionality to the core requirements. In particular, netCDF extension specifications are required for specific encodings. This document indicates which extensions, at minimum, need to be considered in addition to this core for achieving useful implementation specifications.

Reference: NetCDF Binary Encoding Extension Standard: NetCDF Classic and 64-bit Offset Format, OGC Document 10-092r2

Document 10-092r2 specifies the netCDF classic and 64-bit offset file binary encoding formats. This standard specifies a set of requirements that every netCDF classic or 64-bit offset binary encoding must fulfill.

4.2.7 Observation Fusion Computational Viewpoint

The computational viewpoint is concerned with the functional decomposition of the system into a set of services that interact at interfaces.

4.2.7.1 Observation Fusion Services

4.2.7.1.1 Sensor Observation Service (SOS)

Reference: OpenGIS Sensor Observation Service 1.0.0, OGC Document 06-009r6 , http://www.opengeospatial.org/standards/sos

SOS is expected to be used as the service that delivers motion imagery. It may also be used to deliver observation metadata, such as VMTI LDS, with or independently from the imagery itself. SOS may require a new interface, or new filters on an existing interface, in order to accomplish this.

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.

4.2.7.1.2 Web Processing Service (WPS) - Tracks

References:

- *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*
- *Discussions, findings, and use of WPS in OWS-4, OGC Document 06-182r1, http://www.opengeospatial.org/standards/wps*
- *OWS-5 Earth Observation WPS ER, OGC Document 08-058r1, http://portal.opengeospatial.org/files/?artifact_id=30061*
- *OWS-5 Considerations for the WCTS Extension of WPS, OGC Document 08-054r1, http://portal.opengeospatial.org/files/?artifact_id=29406*
- *OWS-6 WPS Grid Processing Profile Engineering Report, OGC Document 09-041r3, http://portal.opengeospatial.org/files/?artifact_id=34977*
- *OWS-7 Web Processing Service Profiling Engineering Report, OGC Document 10-059r2, http://www.opengeospatial.org/standards/wps*
- *The Specification Model — A Standard for Modular specifications, OGC Document OGC 08-131r3, https://portal.opengeospatial.org/files/?artifact_id=34762*

WPS is used in this Testbed to create moving object tracks from object detections in motion imagery.

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. WPS is targeted at processing both vector and raster data.
Several OWS Testbeds have applied the WPS specification to a variety of algorithms (see the OWS-4, OWS-5, OWS-6 and OWS-7 ERs listed above). It has become clear that profiles of the WPS are needed for large classes of algorithms and that those profiles should be developed in a consistent fashion. The need for the consistent approach for profiles was identified in the September 2009 Technical Committee meeting. The TC discussed that perhaps there be a central registry hosted by OGC? The TC asked if should profiles be within OGC namespace or within the namespace of an organization? How could profiles be organized (hierarchical vs. non-hierarchical structure, etc.)? Who should be responsible for defining namespaces and structure?

Development of WPS Profiles needs to be consistent with the specification development guidance of the OGC. The OGC Specification Model (08-131r3) specifies some desirable characteristics of a standards specification that will encourage implementations by minimizing difficulty determining requirements, mimicking implementation structure and maximizing usability and interoperability. The Specification Model discusses development of profiles that is applicable to development of WPS profiles.

4.2.7.2 Services for Notifications, Alerts and Events

In this Testbed, notifications are needed to alert interested parties of the existing of moving object tracks in motion imagery via GeoSMS messaging. Participants will devise a method for notification and discovery and access through the notification to the imagery and bookmarks.

4.2.7.2.1 Event Architecture

References:

- *OWS-7 Event Architecture ER, OGC Document 10-060r1, http://portal.opengeospatial.org/files/?artifact_id=39509*
- *OWS-7 Dynamic Sensor Notification Engineering Report, OGC Document 10-061r1, http://portal.opengeospatial.org/files/?artifact_id=39513*
- *OWS-6 Event Architecture ER, OGC Document 09-032, http://portal.opengeospatial.org/files/?artifact_id=33347*
- *OWS-6 AIM (Aeronautical Information Management Architecture) ER, OGC Document 09-050r1, http://portal.opengeospatial.org/files/?artifact_id=34032*

The OWS-6 Event Architecture Engineering Report describes the first version of an OGC Event Architecture. It does so by defining an abstract architecture and by providing guidance how this architecture can be implemented using existing standards. Several existing OGC specifications deal with aspects of an event architecture to a certain extent. These are, for example, the Sensor Alert Service (SAS), Sensor Event Service (SES) and Web Notification Service (WNS). While the former define a Publish/Subscribe approach for the Sensor Web domain in their specific ways, the latter provides functionality for relaying messages via various protocols.

The OWS-6 Event Architecture ER offers a definition for Event and compares the definition with other terms, in particular "Alert", "Notification", "Action" and "Occurrence".

The ER introduces roles in an event architecture. This set of roles is defined on the basis of the roles used in the OASIS WS-Notification specifications. The roles do not depend on any algorithms performed by an implementing component but rather on the communication pattern being used.

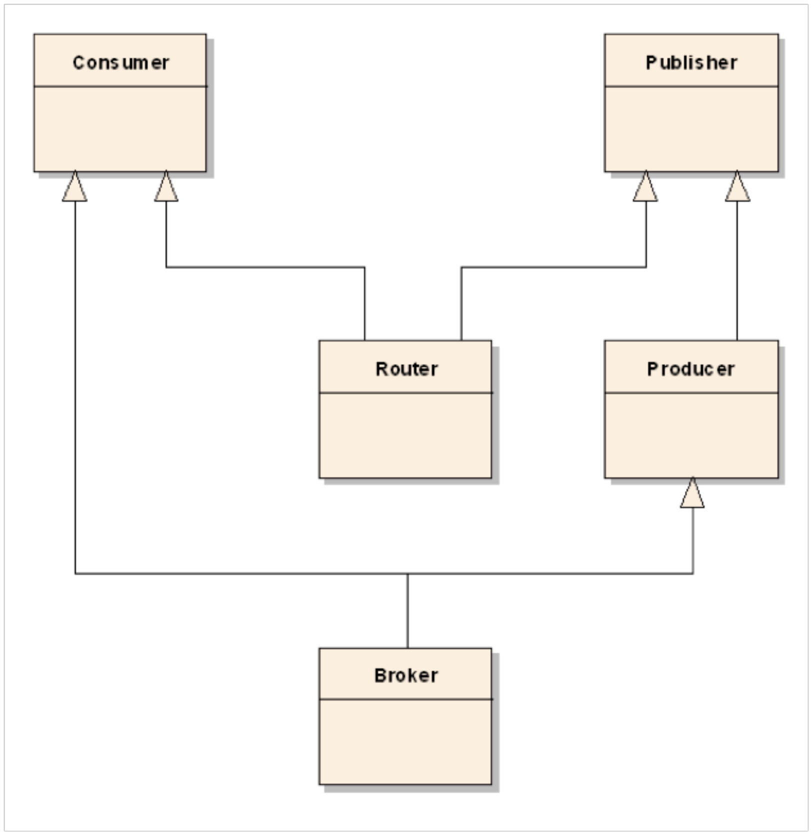


Figure 4-10. Overview of the Roles in the Event Architecture

The OWS-6 Event Architecture ER describes Publish/Subscribe scenarios, where a client subscribes to receive notifications that match given criteria. Pub/Sub effectively introduces a decoupling between the notification publisher and subscriber.

In the WS-* world, Pub/Sub can be implemented with the OASIS WS-Notification standard Another approach from the W3C exists, called WS-Eventing. This standard is not a W3C recommendation yet; however, work is underway at W3C to bring WS-Eventing to recommendation status. The current version of WS-Eventing has a limited set of functionality when compared to WS-Notification. As WS-Eventing is not a final standard, the ER suggests to use WS- Notification for enabling Pub/Sub functionality in all WS-* (sometimes also called SOAP-) bindings / architectural styles in OGC specifications. WS-Notification, being an approved OASIS standard since 2006, has slowly made its way into the web services world, in standards organizations like the Open Grid Forum and also several implementations.

Based on the SWE services SAS and SES as well as the ideas and techniques described in the Event Architecture ER an Event Service was implemented in OWS-6.

In the OWS-6 AIM Thread, and event service was implemented for notification about aviation information updates. This variant shown in Figure 4-11 creates updates through the WFS-T interface to update the database.

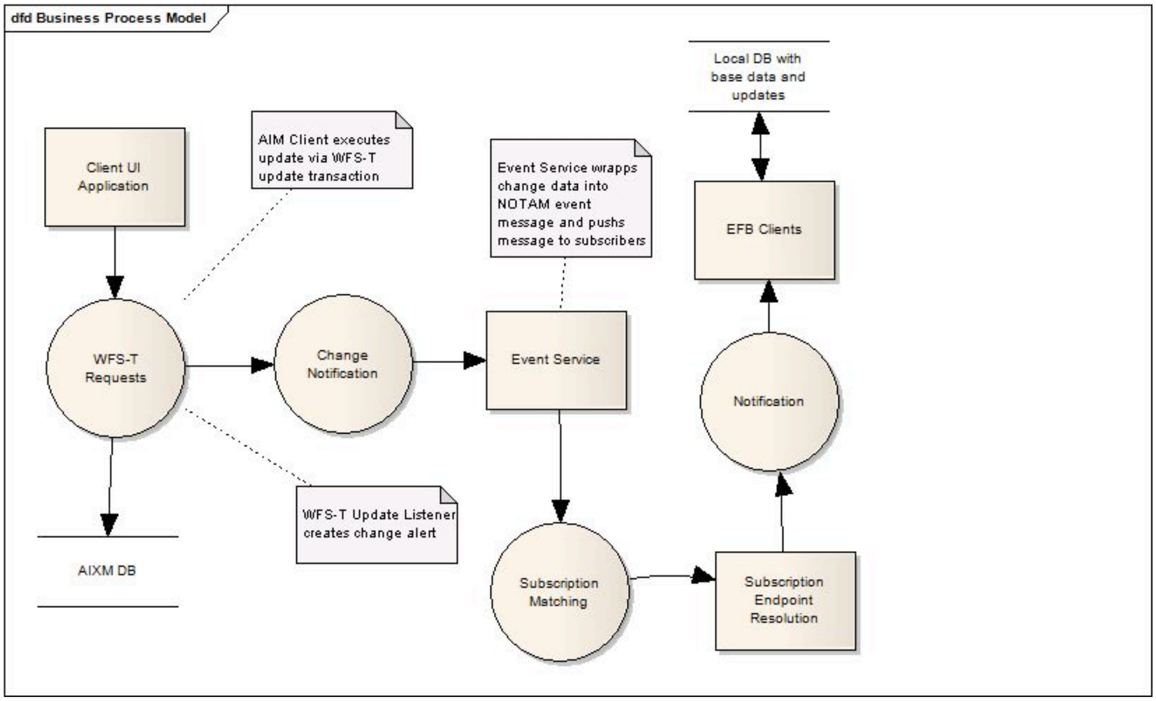


Figure 4-11. OWS-6 AIM Event Service

The OWS-7 Event Architecture ER builds on OWS-6 work, focussing on the realization of a common approach to publish/subscribe functionality for OGC Web Services and event discovery. This ER notes that much work is required still to define an event architecture standard. The OWS-7 Dynamic Sensor Notification Engineering Report describes experiments in that Testbed to track sensors and notify users based on a geographic Area of Interest using SOS.

OWS-8 should leverage work described in the above ERs where applicable. However, this is still an area ripe for innovation, and alternative models for eventing should be considered.

4.2.7.2.2 Sensor Alert Service (SAS)

Reference: Sensor Alert Service Discussion Paper, OGC Document 06-028r3, http://portal.opengeospatial.org/files/?artifact_id=24780&version=1&format=pdf

The Sensor Alert Service (SAS) can be compared with an event stream processor in combination with an event notification system. An SAS processes incoming sensor data continuously. Pattern-matching algorithms identify satisfied alert conditions and start the alert distribution process.

An SAS can *advertise* what alerts it can provide. A consumer (interested party) may subscribe to alerts disseminated by the SAS. If an event occurs the SAS will *publish* an alert and notify all clients subscribed to this event type through a messaging service. Currently, SAS supports XMPP (Extensible Messaging and Presence Protocol) for alert distribution exclusively, although in combination with a Web Notification Service (WNS), it may deliver alerts to other communication endpoints as well. This pattern is likely to change in future versions of the SAS. Currently, the SAS editors are busy doing research on alternative alert and notification mechanisms and protocols.

SAS may be used in the event notification and alerting requirement.

4.2.7.2.3 Web Notification Service (WNS)

Reference: Web Notification Service Best Practice, OGC Document 06-095, http://portal.opengeospatial.org/files/?artifact_id=18776

The Web Notification Service Model includes two different kinds of notifications. First, the “one-way-communication” provides the user with information without expecting a response. Second, the “two-way-communication” provides the user with information and expects some kind of asynchronous response. This differentiation implies the differences between simple and sophisticated WNS. A simple WNS provides the capability to notify a user and/or service that a specific event occurred. In addition, the latter is able to receive a response from the user.

As services become more complex, basic request-response mechanisms need to contend with delays/failures. For example, mid-term or long-term (trans-) actions demand functions to support asynchronous communications between a user and the corresponding service, or between two services, respectively. A Web Notification Service (WNS) is required to fulfill these needs within the SWE framework and should be considered for more general application in the OWS framework.

WNS may be used in the event notification and alerting requirement.

4.2.7.2.4 Notification from Fusion ER

Reference: Fusion Standards Study Engineering Report, OGC Document 09-138, http://portal.opengeospatial.org/files/?artifact_id=36177

The OGC Fusion Standards Study recommends developing dynamic routing based on location. Methods based on open standards are needed to quickly communicate situation conditions and response of decisions makers to a large number of people in a specific geographic region. These announcements need to be coordinated though standards from a variety of communities, e.g., emergency response community using CAP and EXDL-DE. Methods involving dynamic high-speed routing of alerts to geographic regions are needed. This notification needs to include the availability data (maps, digital data, imagery) based on geographic area of interest.

4.2.7.3 SWE Computational Use Cases

4.2.7.3.1 Discovery and Access of Observation using SOS

The SWE Services and Encodings interactions are illustrated in the following figures. In the upper right corner, shows sensors that are registered at a SOS and publish observation results to the services. To be discoverable, sensors, using SensorML, and SOS register at a catalog service. The user in the lower right corner requires observation data and sends therefore a *search request* to the catalog. The catalog responses with a list of SOS service instances that fulfill the requirements. Eventually, the user binds the SOS and retrieves the observation data, encoded in O&M.

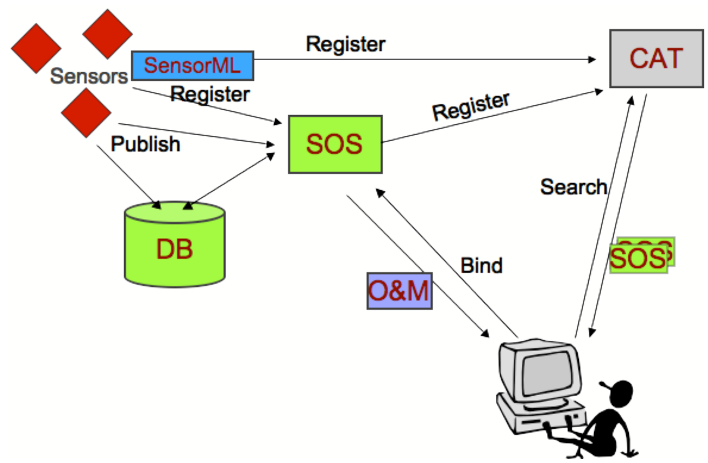


Figure 4-12. SWE Discovery and Access Use Case with SOS

4.2.7.3.2 Notification of sensor reading with SAS and WNS

Often, we are faced with the situation that a client is not interested in all observation results of a sensor, but wants to get notified immediately if a specific situation is observed. Figure 4-13 illustrates this use case.

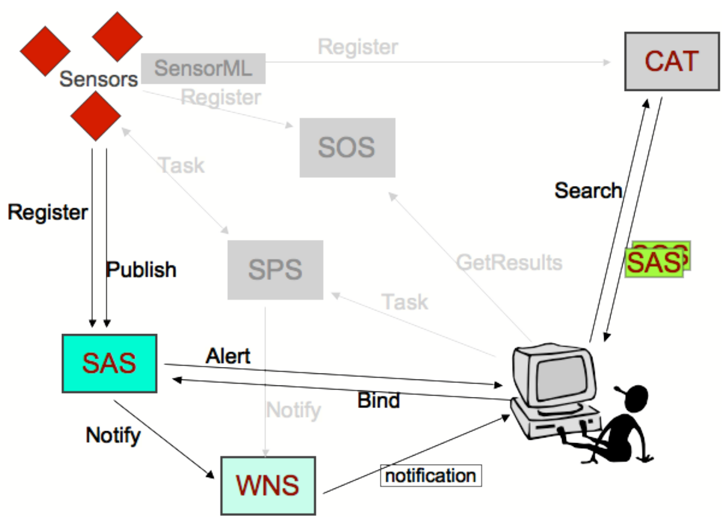


Figure 4-13. Notification with SAS and WNS Use Case

Once again, the client receives information about appropriate SAS from a catalog and subscribes to the SAS. Sensors publish observation results continuously to the SAS. The SAS handles all the filtering and alerts the client if the subscription condition is matched. The SAS either sends the alert directly to the client, or makes use of the WNS in order to deliver the alert message.

For detailed UML Sequence Diagrams for several scenarios, see *Sensor Web Enablement Architecture* (OGC 06-021r2) - Best Practices Document.

4.2.7.4 Web Coverage Service (WCS) Version 2.0

Reference: WCS 2.0 Overview: Core and Extensions, OGC Document 09-153

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 4-14.

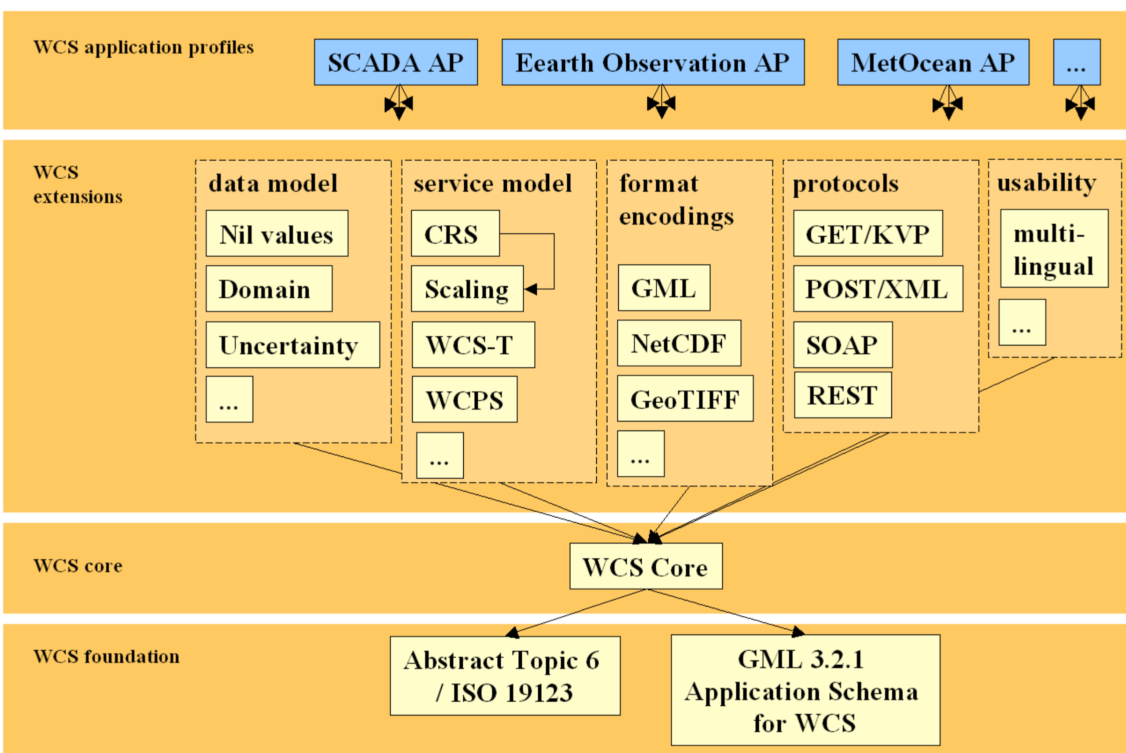


Figure 4-14 WCS specification hierarchy graphical overview

4.2.7.5 WCS 2.0 Application Profile – Earth Observations

A "WCS EO-AP" is under development in HMA and has not yet been presented to the OGC Specification Program, but will be made available before OWS-8 Kickoff.

http://wiki.services.eoportal.org/tiki-download_wiki_attachment.php?attId=922&download=y
Link found on this page: http://wiki.services.eoportal.org/tiki-index.php?page=HMA-FO%20Deliverables

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. Extra requirements can be additions (for example, Dataset Series are introduced by this specification) or constraints (for example, coverages offered are restricted to 2-D rasters).

Implementations of the Earth Observation Application Profile **shall** support at least one of the WCS 2.0 coverage format encodings GeoTIFF, NetCDF, and JPEG2000.

4.2.7.6 NASA RFCs regarding WCS

The NASA Earth Science Data Systems (ESDS) Standards Process Group (SPG) publishes "Request For Comment" documents or RFCs on topics relevant to the NASA Earth Science community. These RFCs are evaluated and can eventually be endorsed as ESDS standards. Two RFCs have been endorsed by the NASA SPG regarding WCS.

Reference: "Interoperability between OGC CS/W and WCS Protocols," ESDS-RFC-014

This document presents lessons related to Open Geospatial Consortium (OGC) protocols that were learned in the course of developing the OGC-Geoscience Gateway. This process surfaced a discontinuity or overlap between the implementation of the CS/W catalog search and the THREDDS Data Server implementation of the WCS *GetCapabilities* protocols. This is rooted in an apparent ambiguity in the CS/W specification with respect to how WCS service access points should be returned in results. Returning simply the service endpoint forces the client to essentially "repeat" the search by issuing subsequent GetCapabilities and DescribeCoverage requests and then searching within them. Returning the Coverage name in addition would short-circuit this, but there does not appear to be a documented standard location for this. In the meantime, clients must make ad hoc arrangements, with potential divergence and suboptimal results. On the other hand, solving this mismatch problem within the OGC protocol family could provide a boost to both CS/W and WCS clients.

Reference: "Lessons Learned Regarding WCS Server Design and Implementation," ESDS-RFC-016

This document provides lessons learned regarding a WCS server implementation with services such as subsetting, reprojection, mosaicking and time series support. This Technical Note presents several challenges encountered in the design and implementation of the WCS server, mostly arising from user access patterns, as well as the approaches taken to address those challenges. The implementation experience seems to indicate that consideration must be given to client and user factors in order for the WCS access to be useful to the target community. In addition to client/user factors, specific characteristics of the datasets to be supported can also exert a strong influence on the implementation requirements of the server. These characteristics are particularly exposed when offering long time periods of data to users that have a particular interest in the time dimension. While this does not negate the usefulness of the WCS protocol in such cases, it does point to challenges in the server implementation.

4.2.7.7 Web Coverage Processing Service (WCPS)

Reference: "WCS — ProcessCoverages Extension," OGC Document 08-059r3

The WCS – Processing Extension is an extension of the WCS Standard based on the Web Coverage Processing Service (WCPS) Language Interface Standard. This extension specifies the service interface encoding to the ProcessCoverages operation, that may optionally be implemented by WCS servers. WCPS provides access to original or derived sets of geospatial coverage information, in forms that are useful for client-side rendering, input into scientific models, and other client applications. As such, WCPS includes WCS functionality and extends it with an expression language to form requests of arbitrary complexity allowing, e.g., multi-valued coverage results.

Reference: "Web Coverage Processing Service (WCPS) Language Interface Standard, " OGC Document 08-068r2

The WCPS defines a protocol-independent language for the extraction, processing, and analysis of multi-dimensional coverages representing sensor, image, or statistics data. Use of WCPS requires a separate, additional specification establishing the protocol, e.g., WCS.

Reference: "Fusion Standards Study, Phase 2 ER," OGC Document 10-184.

WCPS allows ad-hoc filtering, processing, extraction, and analysis of multi-dimensional raster coverages. A protocol-neutral language is defined which can be embedded into both WCS and WPS. This language allows to filter and process **sensor, image, and statistics** coverages like

- 1-D in-situ sensor time series
- 2-D ortho images
- 3-D image time series (x/y/t) and geological data (x/y/z)
- 4-D climate and ocean data (x/y/z/t)
- "abstract coverages" which additionally have non-spatiotemporal axes.

Heterogeneous coverages can be combined in one request, enabling multi-sensor fusion. The language is safe in that no non-terminating requests can be sent, thereby preventing a class of denial-of-service attacks.

The following example shows the principle: "*From MODIS scenes M1, M2, and M3, the absolute of the difference between red and nir, in HDF-EOS, but only those where nir exceeds 127 somewhere inside region R*":

```
for $c in ( M1, M2, M3 ),
    $r in ( R )
where
   some( $c.nir > 127 and $r )
return
   encode( abs( $c.red - $c.nir ), "hdf“ )
```

The Fusion Study, Phase 2 ER has several specific suggestions about how WCPS can be used with Earth Observation data. An outcome of such activities should be **best practices on WCS 2.0 use** to support community uptake.

4.2.7.8 Web Processing Service (WPS) - Coverages

Reference: "OGC Web Processing Service," OGC Document 05-007r7

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 specification is designed to allow a service provider to expose a web accessible process in a way that allows clients to input data and execute the process with no specialized knowledge of the underlying physical process interface or API. The WPS interface standardizes the way processes and their inputs/outputs are described, how a client can request the execution of a process, and how the output from a process is handled.

The WPS specification by itself allows service developers to reuse significant amounts of code in the development of web interfaces, while at the same time facilitating ease of understanding among web application developers. However, fully-automated interoperability can be achieved only through using standardized profiles. While it is possible to write a generic client for WPS, the use of a profile enables optimization of interoperable client user interface behaviour, as well as the publish/find/bind paradigm. To achieve high interoperability, each process shall be specified in an Application Profile of this specification.

Development of WPS profiles is a current activity in several areas of OGC. For example, see "OGC® OWS-7 Web Processing Service Profiling Engineering Report," OGC Document 10-059r2.

4.2.7.9 WPS with Earth Observations

Reference: "OGC OWS-5 Earth Observation Web Processing Services (WPS) Engineering Report," OGC document 08-058r1

Document 08-058r1 describes the use of OGC Web Processing Service (WPS) in earth observation (EO) applications. It provides an overview of web processing services and a description of developments related to earth observation implementations of OGC WPS in the OGC OWS-5 testbed.

Earth observations consist of data collected by satellite, surface and airborne sensors. The data are of multiple types including gridded and point coverages. Processing of these data occur at multiple points across the sensor observation-to-knowledge information flow, including on-board sensor processing, data re-formatting processing, and data analysis processing. Conducting the data flow through web services allows components to be distributed and coupled to form an end-to-end processing chain of services consisting of contributions from diverse and distributed service providers.

OWS-4 implemented workflows for solving various problems, including EO related web processing services for creating derived products from satellite data. In OWS-4, a binary WPS was implemented that provided a "map algebra" interface for two gridded datasets. The binary processing service was used in OWS-4 to calculate a flood product from EO-1 satellite imagery.

OWS-5 built on OGC WPS work in OWS-4 to develop workflows to process observations suitable for decision support including various processing methods for using subsets of observation datasets and predictive model outputs. In particular, two WPSs were developed during OWS-5 for processing, analysis, and tasking services that includes smoke forecasts driven by sensed fire locations, validated by observation derived smoke products, and used to identify spatial-temporal areas of interest for sensor tasking.

4.2.8 Observation Fusion Engineering Viewpoint

4.2.8.1 VMTI CONOPS deployment approach with NITS and SWE

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 by services. Engineering Components handle data. The services and data that are used to define engineering components are defined in the previous viewpoints.

The Enterprise viewpoint identified a set of functions for the VMTI concept of operations and the NITS Tracking Architecture. The engineering components identified below take an initial approach of using those functions as components. The table below identifies services and data for the engineering components.

Component	**Service**	**Data**
Tasking	SPS	"Task Metadata"
Collection	SOS	Video imagery metadata, SensorML
Detections	WPS	O&M, GeoJP2
Geolocation	WPS for Coordinate Transformation	O&M
Attribution	WPS, Integrated Client	O&M
Track Generation	WPS	O&M
Discovery	CSW	Context, Bookmark
NITS reports	SOS	Moving object tracks, NITS, O&M
Fusion/Correlator	WPS, SOS	NITS, O&M, Bookmarks
Common Operational Picture	SOS, CSW, WPS	Context, Bookmarks, NITS

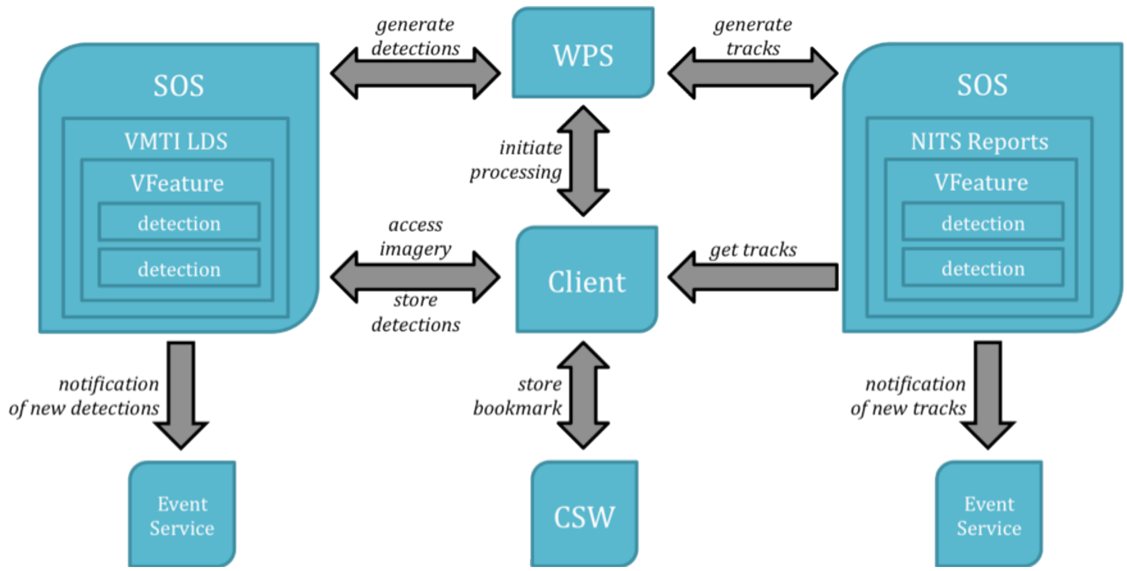


Figure 4-15: Engineering VP for OWS-8 Motion Imagery Bookmarking

Figure 4-15 shows the envisioned component deployment to meet the requirements of OWS-8. An SOS manages access to motion imagery. A client application accesses the imagery, and asks a WPS to generate object detections found within the imagery (or alternately, a human manually generates detections as object detection in motion imagery is out of scope for this Testbed). The detections are saved back into the imagery as VMTI Local Data Set metadata.

The detection generation activity triggers the event notification service to inform interested parties of the update to the VMTI LDS. NITS data is expected to be stored in an SOS. A client, or the NITS SOS itself, will receive these notifications in a target area of interest using the event service with GeoSMS support. This will trigger the generation of moving object tracks using a WPS that processes VMTI LDS from one SOS, and creates moving object tracks suitable for inclusion in NITS data.

The track generation action may also trigger the event notification service to inform interested parties of the update to the NITS reports.

The client application may then review the motion imagery, detections, and tracks and create bookmarks for particular scenes of interest, and stores these in a catalog that provides discovery services for motion imagery and associated bookmarks.

4.2.8.2 VMTI Bandwidth considerations

Reference: "Video Moving Target Indicator Local Data Set," MISB Engineering Guideline, EG 0903.0, 3 September 2009

In its simplest implementation, the VMTI LDS may send thousands of targets to downstream systems by providing a Target ID Number and the Target Centroid Pixel Number within the video frame for each target. At the other end of the scale, the VMTI LDS has scope to include multiple features about each target, image chips of the target, tracking information about the target, and numerous descriptive elements. The bandwidth overhead required to include all this information is very large – especially at 60 frames per second or higher.

Video sensors with frame rates of up to 60 frames per second (fps) are used operationally, and faster systems are expected in the future. It follows that VMTI rates will follow the same trend. In order to conserve bandwidth, a distinction is made between dynamic data, periodic data, and static data. Dynamic data changes continuously and is only valid at a specific instant in time. Periodic data changes periodically and is valid for a period of time. Static data rarely, if ever, changes within a single mission.

VMTI data does not have to be delivered at the frame rate of the motion imagery. Data that rarely changes should only be delivered often enough to assure that it is included in any clip extracted from the motion imagery stream. Dynamic data should be delivered at a rate that is appropriate to the granularity of the intelligence provided. For example, for a target moving at 3 meters per second, a rate of 60 updates a second provides very little value over a rate of 20 updates per second. In that case, while the motion imagery frame rate might be 60 fps, the VMTI update rate need only be 20 "fps".

4.2.8.3 Motion Image Components Data Flows

Access and gelocation of full motion video was an emphasis of the OGC Pilot for Empire Challenge in 2008 (EC08). The as-built engineering components deployed in EC08 for motion video is shown in Figure 4-16. The figure shows interactions and data flows for a collect, process, exploit and disseminate motion video that was demonstrated during execution of the EC08 Pilot.

1. Tiger Shark with GSI camera collects HD imagery at a rate of 1 frame every 1.3 seconds. This data istransmitted to the ERDAS Ground Station where the data is ortho-rectified and processed into NITF format.

2. Navigation data (lat/long/altitude, pitch/roll, true-heading) and the raw JP2 image data is manually loaded onto the BIRI workstation to be served by the "GSI HD:SOS" (an implementation of the OGC Sensor Observation Service interface). Both navigation data and the raw images are served as distinct "observation offers" by the SOS.

3. Two clients applications access the BIRI "GSI HD:SOS" within the COI network domain: TASC PulseNet and BIRI Space Time Toolkit (STT)

4. The same data is manually loaded onto the "OGC Data Storage Node" within the DDTE classified network.

5. The ERDAS "Apollo" data server (an Access and Distribution Node) is equipped with OGC Web Services including, CSW, WCS, WMS and WFS. The ERDAS WMS and WCS services are configured to serve the Tiger Shark images within the DDTE.

6. The "ESRI ArcMap" and "ERDAS Imagine" client applications successfully accessed and processed the imagery served via the ERDAS WMS.

7. The network link to the DDTE in Reston, Virginia was intermittently available and significantly bandwidth-constrained to be of much use for accessing large image files hosted in the DDTE node at China Lake.

8. Tiger Shark imagery was ETL'd to Reston where it was, like at China Lake, served by the ERDAS "Apollo" Data Access and Delivery node to the "ESRI ArcMap" and "ERDAS Imagine" client applications running in Reston.

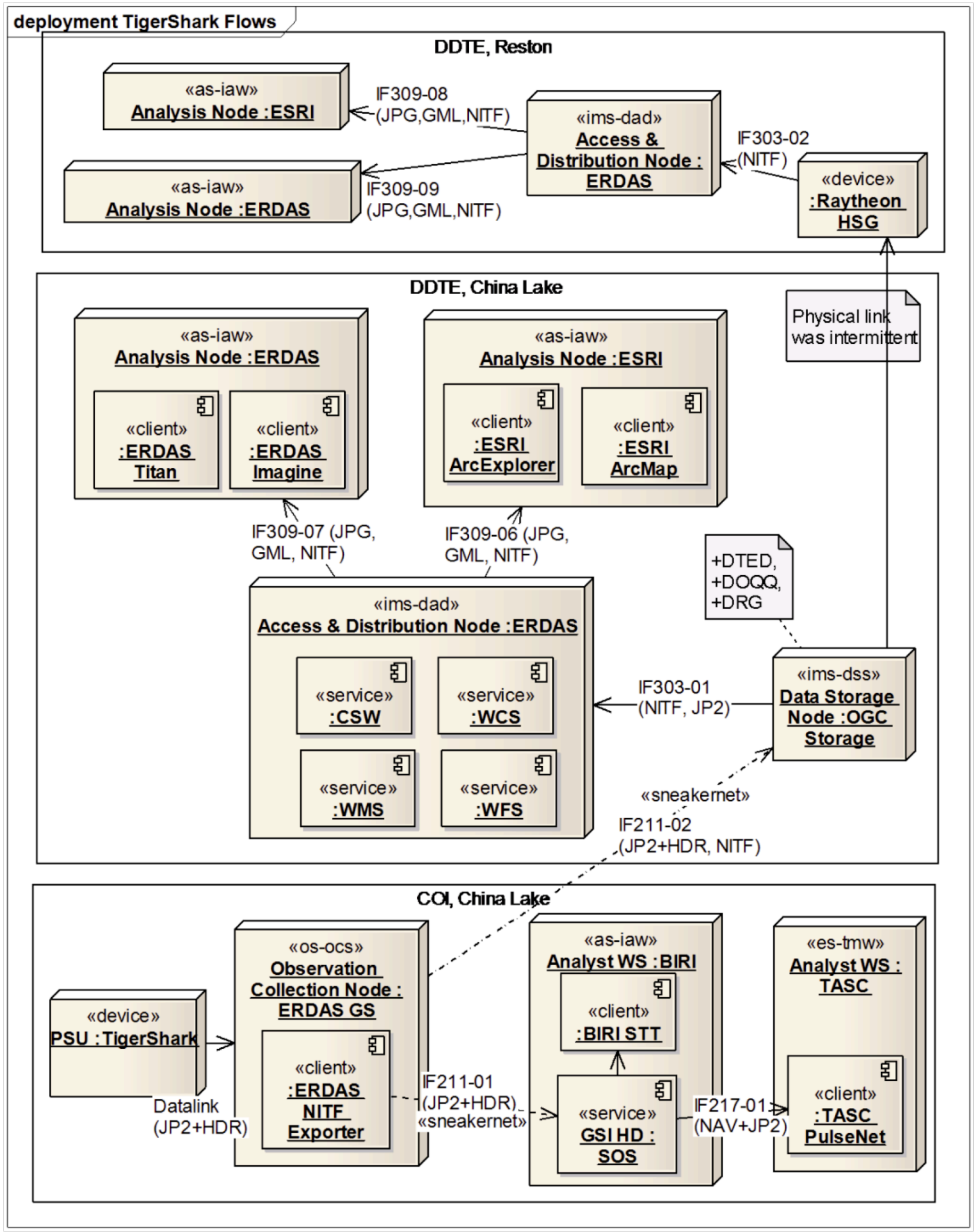


Figure 4-16. EC '08 Motion Imagery Engineering Components

4.2.8.4 Georeferenceable Imagery Deployment Architecture

Reference: OWS-6 Georeferenceable Imagery ER, OGC Document 09-034

OWS-6 had a requirement to allow instant access to time-sensitive imagery at different processing levels, to geo-locate the imagery of interest, and to propagate uncertainty statistics. Much of this work is directly applicable to OWS-8.

Georeferenceable imagery is "a referenceable grid that has information that can be used to transform grid coordinates to external coordinates, but the transformation shall not be required to be an affine transformation". Geolocation of georeferenceable imagery refers to the techniques described in ISO 19130, such as sensor models, functional fit models, and spatial registration using control points.

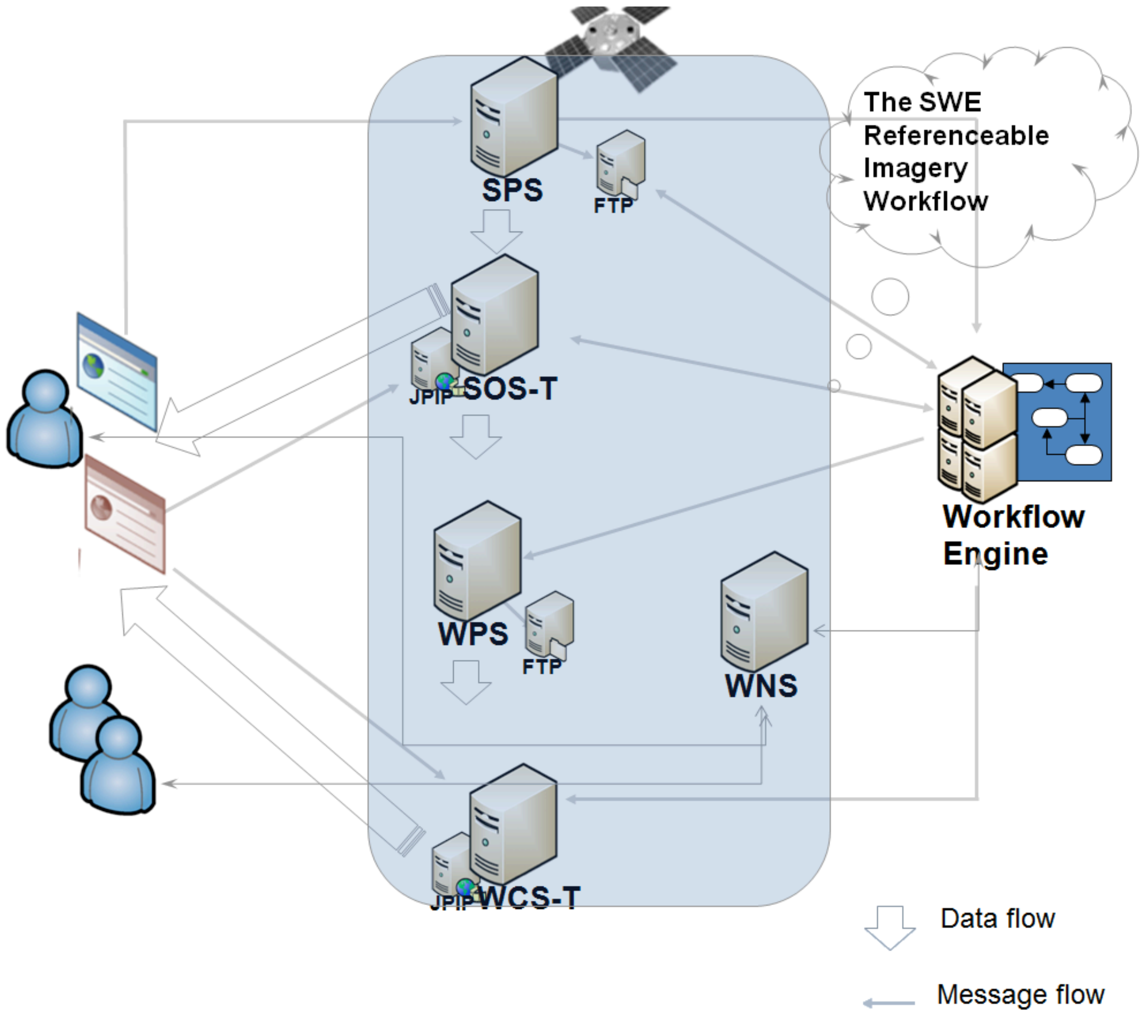


Figure 4-17: Data and Message Flow in Geoferenceable Image Workflow

As shown in Figure 4-17, the Georeferenceable Imagery workflow defined in OWS-6 addresses use cases that exercise the Sensor Web Enablement services, i.e. Sensor Planning Service (SPS), Sensor Observation Service with the optional transaction support (SOS-T), Web Processing Service (WPS), and Web Coverage Service with the transaction support (WCS-T).

The technical foci have been to enable instant access to time-sensitive imagery at different processing levels, to geo-locate the imagery of interest, and to propagate uncertainty statistics. The uncertainty statistics are to be preserved and passed along the workflow by encoding them in the metadata section. The uncertainty statistics include both the quality information of sensing and encoding at sensors or processing nodes and covariance matrices introduced in the processing by comparing the input and outputs at the node. The metadata should be usable within sensor models to describe parameters uncertainty as well as in datasets to report geometric (and radiometric) accuracy.

The mechanism and strategy for uncertainty information to propagate along the workflow have been of the core concepts to be demonstrated in the OWS-6 Testbed. Both rectified imagery and unrectified imagery should have relevant uncertainty information. In the case of unrectified imagery, the metadata should consist of observation (O&M) metadata, sensor model with adjustable parameters, and parameter uncertainty information. In the case of rectified imagery, the metadata should consist of coverage metadata and geometric positioning uncertainty.

Uncertainty information has been proposed to be encoded in SensorML and SWE Common, following the Community Sensor Model WG profiles. A SensorML profile has been developed for this task. Use of UnCertML within SensorML should be considered given the results as presented in the OWS-6 SWE Information Model.

The de-facto industrial workflow scripting language, Business Process Execution Language (BPEL), has been used as the main language for composing the workflow considering the accumulated experiences over several OWS initiatives and the wide support of design tools from either commercial or open-source. This leads to the requirement of adapting each OGC-compliant services to be used in the workflow. The practice to harmonize the service components and chain the services into a mega-service or a workflow can be helpful in the development of individual Web services.

4.2.8.5 Coverage Access and Processing Components

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 by services. Engineering Components handle data. The services and data that are used to define engineering components are defined in the previous viewpoints.

The Enterprise viewpoint the objectives and specific programs provides access to Earth Observation Imagery with access and processing provided by WCS, WCPS and WPS. The engineering components identified below take an initial approach of using those functions as components. The table below identifies services and data for the engineering components.

Component	**Service**	**Data**
Coverage Access	WCS and WCPS	• MODIS (specific products to be identified.) • ENVISAT MERIS L3 demonstration products • ENVISAT ASAR Wide Swath • instruments (e.g. Microwave Limb Sounder) typically produce vertical profiles, • Narrow-swath instruments (e.g., CALIPSO)

		produce vertical cross-sections.
Coverage Processing	WPS	Processing algorithms relevant to Earth Observations, i.e., WPS-EO
Coverage client	Client to WCS, WCPS, WPS	

Figure 4-18 shows the envisioned component deployment to meet the requirements of OWS-8.

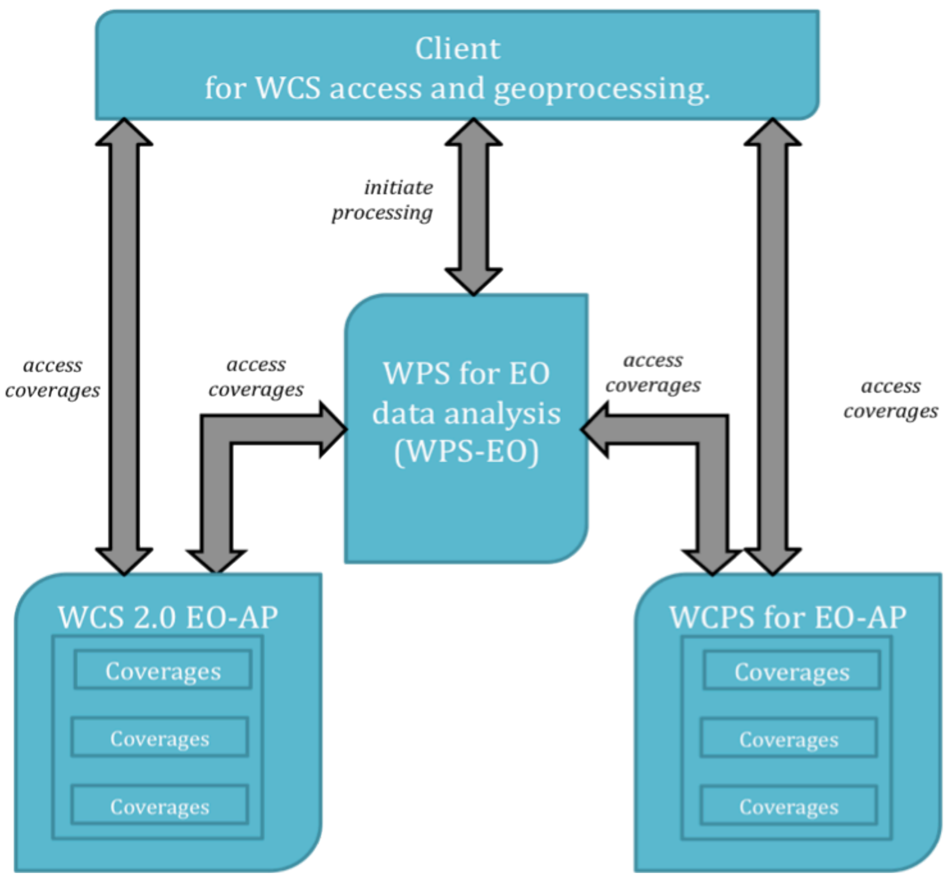


Figure 4-18 Coverage Access Engineering Components

4.2.8.6 Data Sets for Consideration in OWS-8 Coverages

Specific data sets will be determined at the Kickoff.

4.2.8.6.1 MODIS

The MODIS instrument is operating on NASA Terra and Aqua spacecraft. It has a viewing swath width of 2,330 km and views the entire surface of the Earth every one to two days. Its detectors measure 36 spectral bands between 0.405 and 14.385 µm, and it acquires data at three spatial resolutions -- 250m, 500m, and 1,000m.

The many data products derived from MODIS observations describe features of the land, oceans and the atmosphere that can be used for studies of processes and trends on local to global scales.

Of particular interest to OWS-8 are MODIS land products available through the Land Processes DAAC at the U. S. Geological Survey EROS Data Center (EDC)[2].

4.2.8.6.2 ENVISAT MERIS L3[3]

ESA MERIS is a 68.5 degree field-of-view pushbroom imaging spectrometer that measures the solar radiation reflected by the Earth, at a ground spatial resolution of 300m, in 15 spectral bands, programmable in width and position, in the visible and near infra-red. MERIS allows global coverage of the Earth in 3 days.

Taking advantage of the level 2 MERIS data re-processing, a number of demonstration MERIS Level 3 products have been generated for the complete mission. They have been processed using the standard L2 products processed with the last processor version.

Of particular interest the MARIS L3 demonstration products are: aerosol optical thickness and the MERIS Global Vegetation Index (MGVI).

> One land product is the aerosol optical thickness at 443 nm and the angstroem coefficient. The aerosol properties give information on the air quality and aerosol types over land. It can be used as well to correct the land reflectance from the atmospheric effect. Also available as an MARIS L3 demonstration product, is the aerosol optical thickness at 550 nm both over land and sea.
>
> The MGVI is the Fraction of Absorbed Photosynthetcally Active Radiation (FAPAR) calculated from MERIS data. It is a fundamental parameter for monitoring the state of the vegetation and for the environmental studies. It represents the fraction of the solar energy absorbed by the vegetation which is the key parameter for the photosynthetic process.

4.2.8.6.3 ENVISAT ASAR Wide Swath

ENVISAT Advanced Synthetic Aperture Radar (ASAR), operating at C-band, ensures continuity with the image mode (SAR) and the wave mode of the ERS-1/2 AMI. It features enhanced capability in terms of coverage, range of incidence angles, polarisation, and modes of operation.

An operational Level-1B data product offered by ESA from the ASAR Wide-Swath Mode (WSM) is the multi-look detected product (ASA_WSM_1P), intended to support applications that exploit intensity data[4].

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[2] http://edcdaac.usgs.gov/dataproducts.asp

[3] http://earth.eo.esa.int/level3/

[4] http://envisat.esa.int/earth/www/object/index.cfm?fobjectid=4218

ESA makes freely available to the user community a dataset of ASAR products corresponding to the earthquake of Haiti which took place on 12 January 2010. The dataset can be downloaded through the ESA Virtual Archive or directly via the EOLI-SA catalogue from "Other Collections - Virtual Archive - Haiti Earthquake". ESA offers free access to the Virtual Archive also to other data providers allowing data sharing in line with the GEO principles.[5]

4.2.8.6.4 Datasets with Vertical Profiles

This section describes two instruments that typically produce vertical profiles: MLS and CALIPSO. These are provided in addition to the MERIS AOD product discussed earlier. Following the instrument descriptions is a reference to an article regarding use of the data in a web services environment.

- Microwave Limb Sounder

The Microwave Limb Sounder (MLS) instrument on AURA makes measurements of atmospheric composition, temperature, humidity and cloud ice that are needed to (1) track stability of the stratospheric ozone layer, (2) help improve predictions of climate change and variability, and (3) help improve understanding of global air quality. MLS observes thermal microwave emission from Earth's 'limb' (the edge of the atmosphere) viewing forward along the Aura spacecraft flight direction, scanning its view from the ground to ~90 km every ~25 seconds.[6]

- CALIPSO Instrument

Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) was launched to study the impact of clouds and aerosols on the Earth's radiation budget and climate. The CALIPSO satellite comprises three instruments, the Cloud-Aerosol LIdar with Orthogonal Polarization (CALIOP), the Imaging Infrared Radiometer (IIR), and the Wide Field Camera (WFC). CALIPSO is a joint satellite mission between NASA and the French Agency, CNES.

4.2.8.7 Use Cases for Coverage Access and Processing

In this section are listed several references which can be the source of use cases for coverage access and processing. Specific use cases will be determined for the kickoff workshop.

4.2.8.7.1 Use case for Vertical Profiles

Reference: "Access, Visualization, and Interoperability of Air Quality Remote Sensing Data Sets via the Giovanni Online Tool." Prados, Ana, et. al., IEEE J. Selected Topics in Applied Earth Observations and Remote Sensing, V. 3, N. 3, September 2010

This paper describes access, visualization, and analysis of satellite remote sensing products, relevant to global air quality, including vertical aerosol products from CALIPSO. The approach described includes collocation of datasets in analysis of pollution events and to facilitate satellite/monitor comparisons in a fraction of the time compared to traditional methods. Interoperability with multiple protocols permit data sharing with other online

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[5] http://envisat.esa.int/instruments/asar/

[6] http://mls.jpl.nasa.gov/index-eos-mls.php

tools was developed in order to enhance access to the datasets for improved air quality decision-making.

The Prados paper provides a table of relevant services for air quality which is reproduced here as Table 4-3.

Table 4-3 Services Relevant to Air Quality

Service	Application
Latitude-Longitude Map	Air Quality Monitoring and Event
Time Series Plot	Pollution Trends and Air Quality Event Analysis
Animation Maps	Long Range Transport of pollution
Correlation Plots	Satellite/surface aerosol comparisons and satellite intercomparisons
Correlation and Difference Maps	Assess regional differences in agreement between satellite and surface aerosols and among satellite instruments
CALIPSO KMZ Vertical Curtain Plots	3D – Visualization of air pollution when viewed in conjunction with 2D lat/lon maps

4.2.8.7.2 3D Visualization of cloud, aerosol and atmospheric temperature

Reference: "Using KML and Virtual Globes to Access and Visualize Heterogeneous Datasets and Explore Their Relationships Along the A-Train Tracks," Aijun Chen; Leptoukh, G.G.; and Kempler, S.J., U.S. NASA Goddard, Selected Topics in Applied Earth Observations and Remote Sensing, IEEE Journal of Issue Date: Sept. 2010 Volume: 3 Issue:3. http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?arnumber=5462997

This paper first discusses the key technical points for access to and visualization of three-dimensional Earth science data by using KML and Virtual Globes. Then, the Virtual Globes are taken as a virtual three-dimensional platform to synergize horizontal data and vertical profiles along the A-Train tracks to explore the scientific relationships among multiple physical phenomena. Two kinds of scientific scenarios are investigated: a) The relationships among cloud, aerosol and atmospheric temperature, and b) the relationships among cloud, wind and precipitation. The seamless visualization and synergy of multiple versatile datasets facilitate scientists to easily explore and find critical relationships between some phenomena that would not be easily found otherwise.

4.2.8.7.3 WCS access to MODIS LST

Reference: "Development of OGC Framework for Estimating Air Temperature MODIS LST and Sensor Network," S. Ninsawata, S., et. al., WebMGS 2010 - 1st International Workshop on Pervasive Web Mapping, Geoprocessing and Services XXXVIII-4/W13, http://www.isprs.org/proceedings/XXXVIII/4-W13/ID_16.pdf

This study focus on the developing of a comprehensive web based framework for estimating air temperature map from MODIS LST evaluated relationship with in-situ data collected over a distributed sensor network of ground sites. The development is based on various open standards of OGC (Open Geospatial Consortium) Web Service specifications such as Web Processing Service (WPS), Sensor Observation Service (SOS), Web Mapping Service (WMS) and Web Coverage Service (WCS). The availability of high temporal measured air temperature by sensor network provides as a superior ground based data source for estimating air temperature from satellite observation. The MODIS LST dataset as a data source from WMS server was evaluated relationship with near surface air temperature of Live E! Project sensor network weather station from SOS server to calculate air temperature map with on-demand processing capability of developed WPS server requesting satellite data source from WCS server. The developed OGC specification compliance system, that supports interoperability, scalability and robust platform, shows its powerful potential for standard data sharing and on-demand processing interfaces on satellite image and sensor observation data.

4.2.8.7.4 WCS access to AURA HIRDLS in HDF

Reference: "Serving AURA HIRDLS Level 2 Data Through OGC WCS," Peichuan Li, Liping Di, and Genong (Eugene) Yu, Geoscience and Remote Sensing Symposium, 2008. IGARSS 2008. IEEE International, Issue Date: 7-11 July 2008. http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=4779250

More and more Earth science data are made available in HDF-EOS 5 format which is a profile of HDF-5 for Earth science data. New version of OGC Web Coverage Service (WCS) supports data of multiple bands and transaction operation optionally that are desirable for Earth science applications. A WCS server was developed following the new specification in this project. The WCS was applied in serving Aura HIRDLS Level 2 data in HDF-EOS 5 format, including cases for severe weather detection and tracking. System implementation, native support of HDF-EOS 5, example requests and responses, and implementation experiences are discussed in this paper.

4.2.8.7.5 WCS access at ORNL DAAC

Reference: "Discover, Visualize, and Deliver Geospatial Data through OGC Standards-based WebGIS System," Yaxing Wei, Suresh-Kumar Santhana-Vannan, Robert B. Cook, ORNL, Oak Ridge, TN, USA, Geoinformatics, 2009 17th International Conference on Geoinformatics, Aug. 2009. http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=5293520

At the Oak Ridge National Laboratory (ORNL), researchers working on NASA-sponsored projects: Distributed Active Archive Center (DAAC) and Modeling and Synthesis Thematic Data Center (MAST-DC) have tapped into the benefits of Open Geospatial Consortium (OGC) standards to overcome the drawbacks of traditional methods of geospatial data discovery, visualization, and delivery. The OGC standards-based approach facilitates data sharing and interoperability across network, organizational, and geopolitical boundaries. Tools and services based on OGC standards deliver the data in many user defined formats and allow users to visualize the data prior to download. This paper introduces an approach taken to visualize and deliver ORNL DAAC, MAST-DC, and other relevant geospatial data through OGC standards-based Web Services, including Web Map Service (WMS), Web Coverage Service (WCS), and Web Feature Service (WFS). It also introduces a WebGIS system built on top of OGC services that helps users discover, visualize, and access geospatial data.

4.2.8.7.6 WCS access at MODIS by AIST

Reference: "Development of Integration Framework for Sensor Network and Satellite Image based on OGC Web Services," S. Ninsawat, et. al., National Institute of Advanced Industrial Science and Technology (AIST) , 2010 EGU General Assembly, http://meetingorganizer.copernicus.org/EGU2010/EGU2010-3016-1.pdf

A comprehensive web-based system for integrating field sensor and data satellite image based on various open standards of OGC (Open Geospatial Consortium) specifications has been developed. Web Processing Service (WPS), which is most likely the future direction of Web-GIS, performs the computation of spatial data from distributed data sources and returns the outcome in a standard format. The interoperability capabilities and Service Oriented Architecture (SOA) of web services allow incorporating between sensor network measurement available from Sensor Observation Service (SOS) and satellite remote sensing data from Web Mapping Service (WMS) as distributed data sources for WPS.

Various applications have been developed to demonstrate the efficacy of integrating heterogeneous data source. For example, the validation of the MODIS aerosol products (MOD08_D3, the Level-3 MODIS Atmo- sphere Daily Global Product) by ground-based measurements using the sunphotometer (skyradiometer, Prede POM-02) installed at Phenological Eyes Network (PEN) sites in Japan. Furthermore, the web-based framework system for studying a relationship between calculated Vegetation Index from MODIS satellite image surface reflectance (MOD09GA, the Surface Reflectance Daily L2G Global 1km and 500m Product) and Gross Primary Production (GPP) field measurement at flux tower site in Thailand and Japan has been also developed. The success of both applications will contribute to maximize data utilization and improve accuracy of information by vali- date MODIS satellite products using high degree of accuracy and temporal measurement of field measurement data.

4.3 Geodata Bulk Transfer with Synchronization (Gsync) Thread

4.3.1 Gsync Scope

The OWS-8 Gsync thread builds upon OWS-7 work from the Feature and Decision Fusion (FDF) thread, and extends OWS-7 progress to cover key technology areas that could not be addressed within the scope of that initiative. In particular we seek to advance the state of geographic data sharing and synchronization. Past OGC initiatives devised the Geosynchronization specification, which is approaching final standards status. Testing in a variety of situations has identified the need to prototype synchronization mechanisms involving subsets of the full data set as a critical use case. Transfers under conditions of little or no network connectivity are also an important requirement. This test bed pursues that requirement. There is also a need to better define the range of validation, or quality assurance regimes that the Geosynchroniziation specification supports, adding functionality where needed, or simply developing best practices documents to explain how to implement the specification to achieve the appropriate goals.

The following task areas have been identified for the Gsync Thread:

- Geodata Bulk Transfer: The ability to distribute individual data sets and/or collections of data sets in a consistent manner offline and over networks.
- Geosynchronization: Web services and client components to support synchronization and updates of geospatial data across a hierarchical Spatial Data Infrastructure (SDI). OWS-8 enhances the work from OWS-7 to streamline validation scenarios, bootstrap database creation and population, and define query-based subscription mechanisms.

4.3.2 Thread Requirements

4.3.2.1 Bulk Data Transfer Requirements

References:

- *ISO 19115:2003*
  http://www.iso.org/iso/catalogue_detail.htm?csnumber=26020
- *ISO/TS 19139*
  http://www.iso.org/iso/catalogue_detail.htm?csnumber=32557

(Note: next two documents are currently located on a protected-access site, but will become publicly available in early December as the v2.0.0 releases.)

- *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
- *ISO 19110*
  http://www.iso.org/iso/catalogue_detail.htm?csnumber=39965
- *ISO 19107*
  http://www.iso.org/iso/catalogue_detail.htm?csnumber=26012
- DGIWG profile of ISO 19107 – ref?

- *ISO 19136*
  http://www.iso.org/iso/catalogue_detail.htm?csnumber=32554
  (final version text available on OGC Pending Documents page at http://portal.opengeospatial.org/files/?artifact_id=10115&version=1)
- *Efficient XML Interchange (EXI)*
  http://www.w3.org/XML/EXI/
- *ISO 19142 (WFS 2.0)*
  http://www.opengeospatial.org/standards/wfs
- *ISO 19143 (FE 2.0)*
  http://www.iso.org/iso/catalogue_detail.htm?csnumber=42137
  (final version submitted to ISO available on OGC Pending Documents page at http://portal.opengeospatial.org/files/?artifact_id=32680&version=1)

Evaluate, investigate and demonstrate a method for distributing geospatial data from a source system via a mechanism enabling that data to be efficiently ingested in another system. In this scenario, the geospatial data is typically stored in a native format geospatial database, and the mechanism for transfer will either be a WFS response, a data file, or a file system-like folder or container. The geospatial data may either be transmitted "in bulk" over a communications infrastructure or distributed via hard media using "sneaker-net" methods. The communications infrastructure may be either high-bandwidth or very constrained bandwidth - including frequent unreliable connectivity.

Key technical requirements include:

1. the ability to represent a maximal amount of the source geospatial content with **no loss in translation** to the content-exchange format/container
2. **segmentation** of the content-exchange format/container to allow different types of content-components to be extracted or ignored
3. effective **file-size minimization** of the content-exchange format/container (including employing compression technology as appropriate)
4. the assurance of **integrity** in content transmission.

Key container content-components to be supported by segmentation consist of:

1. feature content with associated geometry (including the ability to not have associated geometry in the case of a "pure table")
2. feature associations (including to geometry-less tables)
3. topology
4. ISO 19115-conformant metadata for both individual container-components and the complete container
5. container-level and container component-level checksums to support data integrity assurance (segmentation should be implemented in such a manner that each container-component can function independently of the complete container, thus allowing producers and consumers to leverage only part(s) of the interoperability standard)

Compression, if employed, should consider both overall container size-reduction and the cost of decompression on a disadvantaged client. Minimization of the compression-execution cost should be considered as low priority.

All metadata should conform to ISO 19115 and, where applicable, ISO/TS 19139. All metadata should at a minimum fully support the NSG Metadata Foundation (NMF) - Part 1 (v2.0.0) and, where applicable, the NSG Metadata Implementation Specification (NMIS) - Part 2 (v2.0.0). Note that the NMF/NMIS require support for specific security marking mechanisms beyond those supported by ISO 19115/19139. Metadata for the feature container-component should include a complete feature catalog specification conforming to ISO 19110 and, where applicable, its (draft) Annex E XML encoding.

Topology support should be based on the DGIWG profile of ISO 19107 and where applicable its ISO 19136 encoding.

In addition, it is desirable that the bulk transfer solution incorporate an indexing capability that allows for direct random access to individual items of container-component content - however, this is not a firm requirement and its value/cost must be weighed against other container properties/capabilities.

The mechanism for format/container content-access may be either based on W3C XML technology standards (to include Efficient XML Interchange (EXI)) and open-source technology components, or based on an open Application Programming Interface (API) Specification and open Data Format Specification accompanied by an open-source reference implementation of that API in terms of that format. No specifications, technologies or implementations that are encumbered by Intellectual Property or other legal restrictions shall be employed in the specification of the proposed interoperability standard. The proposed Geodata Bulk Transfer standard must meet the legal requirements for potential adoption and promulgation as an OGC Standard.

In the case of the employment of an XML-based approach then ISO 19136 and ISO/TS 19139 shall be used as the basis for all XML Schemas and extensions to those schemas shall meet all applicable conformance requirements. In the case of a non-XML-based approach then the Data Format and API Specifications should be sufficiently complete that they can be unambiguously employed by any member of the OGC community without the need to "reverse engineer" the API reference implementation. Additionally, the API shall be consistent with the applicable ISO 19100-series conceptual schema specifications.

In the case of an XML-based container it is desirable for container-content to be capable of exchange using ISO 19142 WFS 2.0-based mechanisms with a minimum of (or ideally no) restructuring or transformation. Given a populated source-container, a WFS may be used to transmit the entire, or an ISO 19143 FE-defined subset of the, content to an FE-enabled client for the purpose of either populating a copy of that container (or container-subset) or directly employing that content (or content-subset) in a client-specific manner.

4.3.2.2 Geosynchronization Requirements

References:

- *OWS-7 Geosynchronization Engineering Report, OGC document 10-069r2,* http://portal.opengeospatial.org/files/?artifact_id=39476

- *OGC® Fusion Standards Study, Phase 2 Engineering Report*
  http://portal.opengeospatial.org/files/?artifact_id=36177
- *WFS 2.0*
  http://www.opengeospatial.org/standards/wfs

The Geosynchronization tasks define four areas of enhancement to the Web Feature Service and/or Geosynchronization Service specifications to support better interoperability of geodata sharing technologies. These involve the automated creation of geospatial databases, and varying styles of geospatial data synchronization across platforms. These areas as discussed in detail in the Gsync Enterprise Viewpoint. A short description of the requirements is listed here:

- **Schema initialization:** a process where previously non-existent source or target feature types are created in WFS for the purpose of geosynchronization.
- **Data initialization:** a process whereby data is copied from a source feature type into a target feature type at the beginning of the synchronization process.
- **Validation of data from trusted source:** geosynchronization where no change validation is necessary.
- **Geosynchronization of time stamped and time sliced data:** test the spatio-temporal capabilities of the Geosynchronization specification for synchronizing feature types using both single point and time-sliced methods with close attention paid to the features of WFS 2.0.

4.3.3 Gsync Deliverables

The OWS-8 Gsync thread requires two types of deliverables:

- **Documents: Engineering Reports (ER), Information Models (IM), Encodings (EN), Change Requests (CR):** These shall be prepared in accordance with OGC published templates as defined on the OGC portal. Engineering Reports shall 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. All documents created in response to this program shall include "OWS-8" in the title, to facilitate later literature searches.

- **Implementations (Services, Clients and Tools):** Each of these shall 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 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.

Note that certain draft deliverables will be required by the Interim Milestone at the date shown in the Master Schedule (Main Body, Section 4.6), for use in cross-thread development. These early deliverables will be designated and handled on a thread-by-thread basis.

4.3.3.1 Documents: Engineering Reports (ER), Information Models (IM), Encodings (EN), and Change Requests (CR)

The following documents will be developed in the Gsync thread and submitted to the OGC Specification Program at the completion of the Testbed. (Deliverables specific to each subthread will be identified in later sections.)

Table 4-4: Gsync Engineering Reports (ER), Information Models (IM), Encodings (EN), and Change Requests (CR)

1) OWS-8 Geodata Bulk Data Transfer ER: Method for distributing/sharing geospatial data over a variety of networks and via hard media; including container format; including a standardized topology level based on the DGIWG profile of ISO 19107 and embedded ISO 19115 (and ISO 19139 where applicable) metadata; evaluate compression techniques.	ER
2) OWS-8 Best Practices for Use of Geosynchronization ER: for validation of data from trusted source, and use of timestamped and time sliced data	ER
3) OWS-8 Change Request to WFS-T 2.0: for Schema and Data Initialization	CR

4.3.3.2 Implementations: Services, Clients, and Tools

Implementations of the following services, tools and data instances will be developed in this thread, tested in Technology Integration Experiments (TIEs) and invoked for cross-thread scenarios for demonstration events:

Table 4-5: Gsync Required Services, Clients and Tools

1) Geodata Bulk Data Transfer Export Service	Service
2) Schema and Data Initialization Service	Service
3) GSS for Time Stamped and Time Sliced Data Service	Service
4) Geosynchronization Client: Interfaces with all of the services above, including support for WFS 2.0 and the Geosynchronization service.	Client

4.3.4 Gsync Enterprise Viewpoint

4.3.4.1 Bulk Data Transfer Enterprise Viewpoint

The requirement for a mechanism to distribute and share geospatial data reflects the modern day situation of trying to transmit important information across a wide array of varying communication networks. This transfer is typically from geospatial database(s) via a file or "container" to be ingested in another system that will use this data. Geospatial foundation data is typically very large and while network-based system initialization is desirable it may not always be supportable given potentially constrained-bandwidth networks with unreliable connectivity (DIL: Disconnected, Intermittent, Low-bandwidth). In these circumstances initial geospatial data foundation loads may need to be transferred via hard-drives and other hard media transfers. From a systems-perspective it is desirable that regardless of whether the bulk geodata package is moved physically (DIL scenario) or electronically (robust communications bandwidth) that the client should be able to act on it using highly similar (if not the same) mechanisms.

As illustrated in Figure 4-19, in this scenario the geospatial data is typically stored in a native format geospatial database and the geospatial data content is initially restructured in accordance with a standard content-exchange format/container, The geospatial data may either be transmitted using a web service (*e.g.*, WFS employing FE), a file exchange protocol (*e.g.,* FTP using named files) or manually distributed via hard media. The recipient may need to reconstitute the geospatial data into their preferred/native geospatial database format before use.

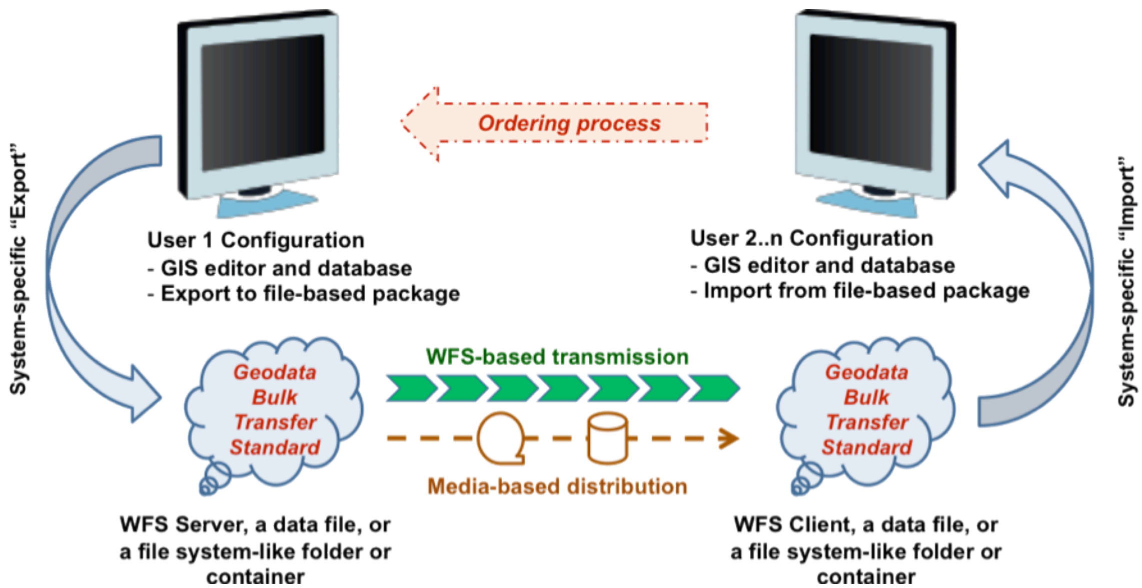


Figure 4-19 Geodata Bulk Transfer Scenarios

The proposed Geodata Bulk Transfer Standard consists of a conceptual 'container' where the 'parts' (defined below) function independently of the whole container thus allowing potential producers and consumers to leverage only part of the interoperability standard. The 'container' should support the ability to:

1. Define the relationships between feature types
2. Maintain integrity (container check sums)
3. Provide a compression methodology optimized for transmission and consumption on disadvantaged clients
4. Describe the parts or feature types within the container [AGEA-Syndication]
5. Define the metadata for the whole container as well as the parts of the container
6. Provide for direct random access (desirable but not mandatory)

In the Enterprise Viewpoint there are three bulk data transfer scenarios from the perspective of the customer (User 2 in Figure 4-19):

1. When sufficiently robust communications are available it is advantageous to employ WFS/FE as the mechanism for both ordering and content-delivery based on a suitable MIME type.
2. In some environments it may be appropriate to communicate ordering information using out-of-band mechanisms (*e.g.*, telephone, email) resulting in the preparation of a bulk data package for either later pick-up by the customer using FTP when sufficient bandwidth is available or direct physical media shipment to the customer.
3. In other environments it might be possible and useful to employ an analogue to WFS/FE to support a flexible ordering process but direct the "pick-up" to occur via FTP or physical media shipment.

It is not specifically intended to explore this last possibility during OWS-8 however this scenario may be explored in the future and should be considered as part of the design/analysis process during OWS-8.

While the second ("non-web") scenario is the more important use case in OWS-8, from a systems-perspective it is desirable that regardless of whether the bulk data package is moved physically ("sneaker-net" scenario, use-case #2) or electronically (services-based scenario, use-case #1) the customer application should be able to act on it using highly similar (if not the same) mechanisms.

4.3.4.2 Geosynchronization Enterprise Viewpoint

The Geodata synchronization tasks define three areas of enhancement to the Web Feature Service and/or Geosynchronization Service specifications to support better interoperability of geodata sharing technologies. These involve the automated creation of geospatial databases, and varying styles of geospatial data synchronization across platforms.

Schema Initialization

Schema initialization is a process where previously non-existent source or target feature types are created in WFS for the purpose of geosynchronization. However, the WFS specification does not currently define operations that allow new feature types to be created in a server.

An initial capability was demonstrated in OWS-7 under the Geosynchronization topic. OWS-8 expands this capability and advances feature type creation capability in the WFS specification.

This task is different than populating an empty database. In this case, the user would create a new schema or modify an existing one, which could then be populated. A capability is needed to search existing schemas to see if a suitable element exists. If not, the user can create a new feature type or modify an existing one to include the relevant information. Some form of review process may be necessary.

Data Initialization

Data initialization is a process whereby data is copied from a source feature type into a target feature type at the beginning of the synchronization process. This is done to initialize the target feature prior to additional geosynchronization. Data initialization is important for the dynamic environment where new services are brought on-line and they need to be brought up-to-date with current situational information.

To support this transfer, a capability is needed in the WFS specification to describe the size of the transaction (in terms of storage) prior to conducting the initialization. Three basic types of initialization, all based on WFS, should be developed. These include Full Copy Data Initialization (Historical Initialization), Partial Copy Initialization, and No Copy Data Initialization (Point in Time Forward). For all types, it is important that the copy is time-stamped to indicate the time and date of the last change applied to the copy.

- **Full Copy Data Initialization (Historical Initialization):** Full copy initialization involves obtaining a copy of all instances of a source feature type and loading them into a target feature type. The copy may be made via a WFS query or by copying the data to a physical media. Full copy initialization would be used when new target sites are brought online and need to obtain a copy of the entire source feature data prior to additional geosynchronization.
- **Partial Copy Initialization:** Partial copy initialization is similar to full copy data initialization except that a subset of the source features is identified for geosynchronization. The copy set may be created by specifying a WFS filter that may include any logical combination of temporal, spatial and scalar property constraints.
- **No Copy Data Initialization (Point in Time Forward):** Unlike full and partial copy initialization, geosynchronization can begin at any point-in-time without the need to seed the target feature type with data from the source feature type. The only requirement is that the target feature type exists or is created using Schema Initialization. All future changes are integrated from the start of no copy data initialization.

Validation of Data from Trusted Source

The Geosynchronization specification has been demonstrated for applications where data is created by a user, validated by a reviewer, and propagated to subscribing databases. This solution is ideal for workflows with multiple users inputting data in near real time.

OWS-8 evaluates a "base plant" scenario for Geosynchronization, possibly using WFS. In this scenario, the base plant operation utilizes an internal data production cell and the data is reviewed and validated prior to synchronization, presumably by a trusted process. The base plant would like to use Geosynchronization for synchronizing and propagating data, but does not want to revalidate the data as part of the process. Specifically, *feature-by-feature validation is to be avoided*. It would, however, be acceptable to have a single, bulk validation step for all the edits, although it would be better if no additional step were required. This functional requirement for supporting simplified data validation from a trusted source is included in the Geosynchronization Service Standard 1.0. However its usage is not well documented and may be ambiguous. The requirement for this task is to identify and document best practices in use of this functionality.

Geosynchronization for Time Stamped and Time Sliced Data

The WFS 2.0 draft specification allows for time stamped and time sliced feature data access. The purpose of this task is to test the spatio-temporal capabilities of the Geosynchronization specification for synchronizing feature types using both single point and time-sliced methods. Testing should be done with publisher, reviewer, and 'effective' time, as well as time within the source feature type (for example, a spatio-temporal feature that changes over time). Users should be able to filter data based on any of the time information. This test will document the ability of Geosynchronization to support temporal requirements, and recommend enhancements as needed.

4.3.5 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 Geosynch thread activities in the following areas:

- Geospatial data encoding
- Geospatial metadata encoding
- Efficient XML encoding
- File collection encoding
- Data query language

4.3.5.1 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.

4.3.5.2 Geospatial metadata encoding

Relevant Specifications and Documents:

- *ISO 19115:2003 – Geographic information – Metadata*
- *ISO/TS 19139:2007 – Geographic Information – Metadata – XML Schema Implementation*

(Note: next two documents are currently located on a protected-access site, but will become publicly available in early December as the v2.0.0 releases.)

- *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.

4.3.5.3 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.

4.3.5.4 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.

4.3.5.5 Data Query Language

Relevant Specifications:

- *OGC Filter Encoding Implementation Specification 2.0; ISO 19143 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)

FE 2.0 will be used in this thread to develop the more advanced queries needed to implement the timestamped and time sliced data requirements.

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. The FE 2.0 has recently been jointly approved by ISO and OGC and will soon become available on the public OGC website.

4.3.6 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.

4.3.6.1 Bulk Data Transfer

The geodata bulk transfer task requires a geospatial database to export information to a geospatial content-exchange format/container whose characteristics are discussed above in the Information Viewpoint section. This format/container may be imported and exploited by a variety of clients ranging from a similar geospatial database to a mobile field device. The components shall interact via a variety of network regimes, including no connection to a network.

The bulk data transfer requirement specifies that a software component generate a "bulk data file" that contains one or more geospatial data files and metadata along with "container" information that describes the contained data files. This requirement does not require that this activity be performed in a service-oriented architecture, but is intended to integrate "gracefully" into such an architecture. Presumably, data would be exported or otherwise transferred from an "origin geospatial database" or directory to the bulk data file. The means of doing so is not exposed at the interoperability layer. Only the format/container itself and the means of accessing it have open, interoperability requirements. Accordingly, bulk data file import into the "target geospatial database" happens in the same way.

4.3.6.2 Geosynchronization

Relevant Specifications and Documents:

- *OWS 7 Engineering Report - Geosynchronization service*, OGC document 10-069r2, http://portal.opengeospatial.org/files/?artifact_id=39476
- *OpenGIS® Web Feature Service 2.0 Interface Standard*, OGC Document 09-025r1, http://www.opengeospatial.org/standards/wfs

The Geodata synchronization tasks define four areas of enhancement to the Web Feature Service with Transactional interfaces (WFS-T) and/or Geosynchronization Service specifications to support better interoperability of geodata sharing technologies. These involve the automated creation of geospatial databases, and varying styles of geospatial data synchronization across platforms.

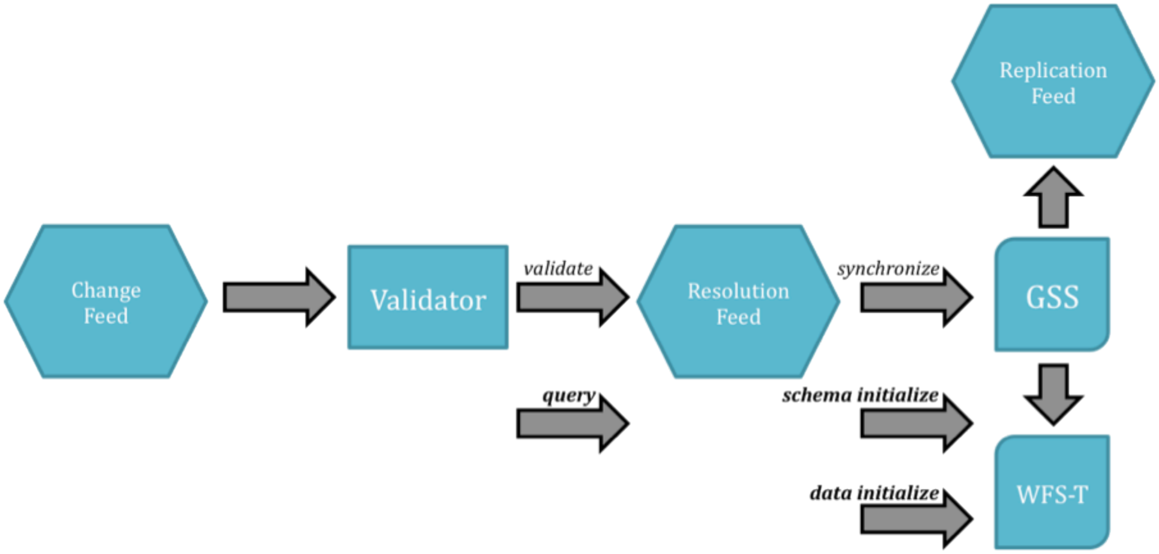


Figure 4-20: Computational Viewpoint–Geodata Synchronization

Figure 4-20 shows the architecture for the Geosynchronization service, along with additional operations required by this Testbed shown in bold type. The normal computational process for geosynchronization starts with a "change feed." This is a listing of proposed data updates that may be created in any number of ways—by GIS software editing data, by a web client filling out a form, via a geospatial text message, etc. In any case, the synchronization "request" begins with an update to the change feed. Next, a validator—a human user or a software component—decides whether or not the suggested change should be applied. Those decisions are captured in a "resolution feed."

For the automated validation requirement of this thread, it may serve to simply remove the validation step and the associated resolution feed from the synchronization process.

To satisfy the timestamped and time-sliced data query requirements, the process of moving from the change feed to the resolution feed may involve applying a filter, or query, to the change feed instead or in addition to going through a validation process.

However, the changes proposed in the change feed are mediated, the resolution feed will eventually contain feature updates, additions, and deletions described as WFS-T operations. In the current Geosynchronization model, these changes are handled by a geosynchronization component which knows how to invoke the WFS-T operations on a WFS-T service to register the changes in the database. In previous work on geosynchronization, it was assumed that the data schema existed in the target WFS-T. If not, creation of this schema was assumed to be external to the interoperability layer. In other words, database schema creation was assumed to be performed manually. This thread defines a requirement for interfaces to the WFS-T for schema and initialization. Participants will define how this requirement affects the geosynchronization specification, if at all.

The final step of geosynchronization is to publish a "replication feed." This is akin to a change log in a traditional database. However in this case, the log is in an open, interoperable format. It may be used by a third parties as another "change feed" so that the synchronization process is chained to another class of downstream users. This feed may be quite different from the initial change feed, as it may have been modified by the validation and query/slicing steps performed along the way.

4.3.7 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.

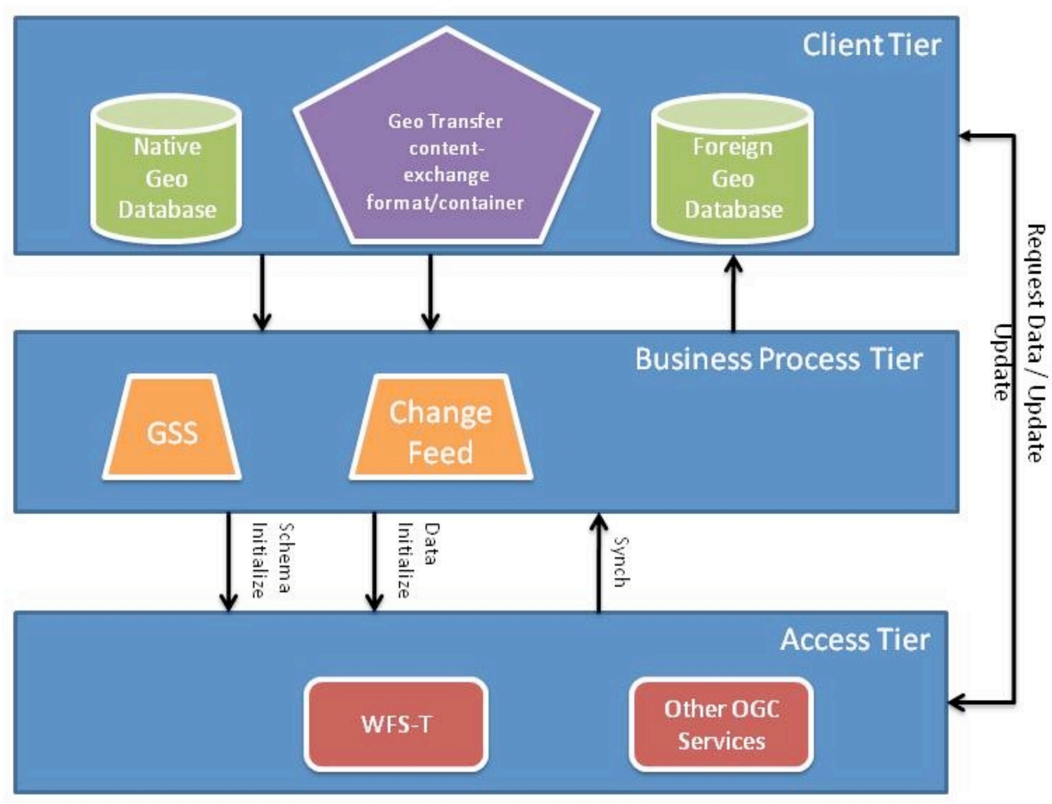


Figure 4-21. Three-tier architecture and interactions

4.4 Cross-Community Interoperability (CCI) Thread

4.4.1 CCI Thread Scope

The CCI thread extends OWS-7 progress to cover key technology areas that could not be addressed within the scope of that initiative. This thread seeks to increase interoperability within communities sharing geospatial data, including advancing of interoperability among heterogeneous data models, advancing strategies to share styles to provide a more common and automated use of symbology, improvement of KML, and advancing schema automation allowing communities to better share there information artifacts. The main task areas are as follows:

- Advancement of semantic mediation approaches to query and use data based on different heterogeneous data models, which are available via OGC Web Feature Service.
- Advancement of the use of style registries and styling services.
- Advancement of the use of KML.
- Advancement of the use of UML/OCL for Schema Automation on Domain Models.

4.4.2 CCI Thread Requirements

4.4.2.1 Semantic Mediation Requirements

References:

- *Catalogue Service for the Web* http://www.opengeospatial.org/standards/cat
- *Geographic Information Framework Data Standard* http://www.fgdc.gov/standards/projects/FGDC-standards-projects/framework-data-standard/framework-data-standard
- *North American Profile of ISO 19115:2003, Geographic information – Metadata* http://www.fgdc.gov/standards/projects/incits-l1-standards-projects/NAP-Metadata
- *NSG Metadata Foundation (NMF) - Part 1 (v2.0.0)* Link will be available in December 2010.
- *NSG Metadata Implementation Specification (NMIS) - Part 2 (v2.0.0)* Link will be available in December 2010.
- *OGC 09-140r2 NSG Profiles Plugfest Engineering Report*, http://portal.opengeospatial.org/files/?artifact_id=36336&version=2
- *ISO/IEC FDIS 19142: Geographic information - Web Feature Service, 2010-04-26, OGC 09-025r1* http://www.opengeospatial.org/standards/wfs
- *RDF - Resource Description Framework* http://www.w3.org/RDF/
- *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
- *SKOS* http://www.w3.org/TR/skos-reference/
- *NSG TDS Documentation*: https://nsgreg.nga.mil/TopographicTerrestrial.jsp
- *USGS NationalMap*. http://nationalmap.gov/
- *USGS Transport Data Model*. http://nationalmap.gov/transport.html

- *USGS National Map Framework Web Feature Services*. http://nationalmap.gov/framework.html
- *DoD/IC Coordinate Reference Systems Dictionary* http://metadata.ces.mil/mdr/ns/GSIP/crs
- *RIF Rule Interchange Format*. http://www.w3.org/TR/rif-overview

The purpose and requirements of this task are to investigate, evaluate, and demonstrate the benefit of semantic mediation approaches (e.g. ontologies, mappings, SPARQL) to query and use data, based on different data models, which are available via OGC Web Feature Services. Data Models that will be used are as follows:

- Topographic Data Store (TDS) data model from NGA
- National Map Data Model from USGS

4.4.2.1.1 Develop an RDF model of the portions in common among the above data models, to be called Rosetta Mediation Model (RMM). This model captures the core elements of NGA and USGS Data Models and can be a sub model of the NGA and USGS Data Model.

4.4.2.1.2 Develop an OGC Mediation Component that allows a client to query multiple data sources in real time, by using a specified Data Model, regardless of the different source Data Models that are being queried.

4.4.2.1.3 For each Data Model provide an RDF encoding of the core elements of each model. The elements are consider core if they can be mapped to the RMM model: Therefore it is required to develop the following:

a) RDF Ontology representing components of the NGA Data Model
b) RDF Ontology representing components of the USGS Data Model

4.4.2.1.4 Provide data from previous models via WFS 2.0 / FE 2.0 services. It is possible that existing servers will suffice. The following are required:

a) WFS that provides data based on the NGA Data Model. This WFS should support an MDR-published CRS available in the DoD/IC Coordinate Reference Systems Dictionary. For example the "standard" WGS84 Ellipsoidal CRS would be specified with the srsName value of "http://metadata.ces.mil/mdr/ns/GSIP/crs/WGS84E_2D"
b) WFS that provides data based on the USGS Data Model.

4.4.2.1.5 Develop mappings (e.g. skos:exactMatch) among different CRS models. Some of the data sources will use EPSG and others will use CRS specifications maintained in the DoD/IC Coordinate Reference Systems Dictionary.

4.4.2.1.6 Develop mapping rules between community data models and the RMM model. This can be achieved using RDF related technologies such as SKOS (e.g. skos: exactMatch), OWL or Rule Interchange Format (RIF) based languages. The following is required:

a) Mapping from the NGA Data Model ontology to RMM
b) Mapping from the USGS Data Model ontology to RMM

4.4.2.1.7 Advance a client that is capable of:

a) Requesting and consuming data based a user selected Data Model.

b) Applying a symbol set such as GeoSym, MILSTD 2525, or a machine dependent symbols to the core data, which is the data that can be mapped from other sources. See further details in the Portrayal Services Requirements section following.
c) Applying a mechanism to queue Non Core data elements so that the operator can assign a symbol to them or decide not to use them.

4.4.2.2 Portrayal Services Requirements

References:

- *KML* http://www.opengeospatial.org/standards/kml
- *Feature Portrayal Service and Styled Layer Descriptor* http://www.opengeospatial.org/standards/sld
- OGC 04-040 - *Style Management Services for Emergency Mapping Symbology* http://portal.opengeospatial.org/files/?artifact_id=7470
- *Symbology Encoding*, http://www.opengeospatial.org/standards/symbol
- *OWS-7 Engineering Report - Aviation Portrayal*, OGC document #10-127r1, http://portal.opengeospatial.org/files/?artifact_id=40134
- *Catalogue Service for the Web*, http://www.opengeospatial.org/standards/cat

This requirement is to investigate, evaluate and demonstrate the ability to use portrayal registries for KML, SLD and/or SE. The DGIWG Portrayal Registry will be used to advance a CSW ebRIM profile.

The DGIWG Portrayal Registry is a repository of symbols and portrayal rules that link symbols to features. OGC Symbology Encoding (SE) is the standard XML encoding for these portrayal rules and symbols. The DGIWG Portrayal Registry will be able to provide a Symbology Encoding (SE) document for rules and symbolizers for a symbol set.

The requirements on a portrayal registry supporting KML data are similar to that of a portrayal registry supporting other OGC Portrayal Services. The understanding and use of a KML portrayal registry will be advanced.

4.4.2.2.1 Develop a CSW ebRIM Profile for Portrayal Registry.

4.4.2.2.2 Develop a CSW ebRIM interface to the DGIWG Portrayal Registry (to evolve into portrayal extension package of CSW ebRIM).

4.4.2.2.3 Advance the use of SLD documents by creating a link between a SLD document in a Get Map Request and SE from the portrayal registry CSW ebRIM interface (Reference OGC SLD Profile of WMS Change Proposal 10-181). Intent for this extension point is to allow a reference to a rule set ID in a portrayal registry to be included in a SLD document.

4.4.2.2.4 Evaluate and demonstrate if the same style resources could be used for OGC Portrayal Services and KML data, i.e. KML and SLD/SE would simply be different representations of the same resource.

4.4.2.2.5 Evaluate the use of portrayal registries within KML. KML features reference styles, while OGC Portrayal Service requests reference SLD (containing a set of layers with one or more styles). These resources would need to be managed consistently in the registry.

4.4.2.2.6 Improve the portrayal registry service by allowing styles to be accessed from the registry using a URL with a fragment identifier to reference the particular Style/StyleMap element in the KML document.

4.4.2.2.7 Improve the portrayal registry service by making the URL above mentioned to persistent - or available at least as long as anyone might reference the particular style(s).

4.4.2.2.8 Identify need for extension points to support military symbology, including MIL-DTL-89045A, GeoSym and MIL-STD-2525C, Common Military Symbology.

4.4.2.2.9 Develop a small sample set of symbols (SLD/SE and KML) for demonstration purposes.

4.4.2.3 KML Requirements

References:

- *KML* http://www.opengeospatial.org/standards/kml
- *Feature Portrayal Service and Styled Layer Descriptor* http://www.opengeospatial.org/standards/sld
- *OGC 04-040 Style Management Services for Emergency Mapping Symbology* http://portal.opengeospatial.org/files/?artifact_id=7470
- *Symbology Encoding* http://www.opengeospatial.org/standards/symbol

4.4.2.3.1 Add KML support for child elements in a BalloonStyle to specify, for example, styles and scripts.

4.4.2.3.2 Advance KML encoding support for different styles per feature type. KML encoding rules do not support different styles per feature type. A similar filtering mechanism as in SLD/SE would need to be supported by the encoding rule to achieve the styling of features on the same level of granularity. Currently within KML all features of a particular feature type are rendered using the same style. It is required a more refined mechanism to distinguish for example different building symbology based on building functions or conditions

4.4.2.3.3 Advance KML encoding to support layers. KML does not have a concept of layers and styles associated with these layers. Instead, each feature references the style in which it should be rendered.

4.4.2.4 Schema Automation Requirements

References:

- NAS 2.0 – *Part 1: https://nsgreg.nga.mil/as/view?i=81050 (also see: https://nsgreg.nga.mil/as/registers.jsp?register=NAS)https://nsgreg.nga.mil/as/view?i=81050*
- *OGC 10-088 OWS-7 Schema Automation ER* http://portal.opengeospatial.org/files/?artifact_id=39408&version=1
- *ShapeChange*, http://www.interactive-instruments.de/index.php?id=28&L=1
- *Schematron second edition draft* - http://www.itscj.ipsj.or.jp/sc34/open/1419.pdf

The goal of this task is to build on the OWS-7 Schema Automation activity, for improved schema automation with the ShapeChange UML-to-GML tool as used with the U.S. National System for Geospatial Intelligence (NSG) Application Schema (NAS).

4.4.2.4.1 Develop and implement in the ShapeChange tool,support for ISO 19139 UML/OCL-to-XML application schema encoding rules to include metadata profiles (both restriction and extension), possibly based on the xsdDerivation UML tag concept.

4.4.2.4.2 Implement in ShapeChange tool the use of OCL/Schematron rules for specifying codelists based on persistent net-accessible resources, including:

- http://metadata.ces.mil/mdr/ns/GPAS/codelist
- http://metadata.ces.mil/mdr/ns/GSIP/codelist
- http://metadata.ces.mil/mdr/ns/GSIP/uom
- http://metadata.ces.mil/mdr/ns/GSIP/rs
- http://metadata.ces.mil/mdr/ns/GSIP/crs

4.4.2.4.3 Implement in ShapeChange support for OCL "let ... in" (and related) expressions, and optional support for XPath 2.0-based Schematron (second edition, draft).

4.4.2.4.4 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 (see Section 4.4.2.3).

4.4.2.4.5 Develop UML/OCL-to-XML application schema encoding rules for the family of Sensor Web Enablement (SWE) standards. ISO 19136 includes Annex E (normative) *UML-to-GML application schema encoding rules* for the purpose of consistently creating GML-based application schemas (XSD) from UML/OCL-specified domain models. Comparable encoding rule specifications are required in support of the schemas specified in SWE standards. ShapeChange and other tools (*e.g.*, FullMoon/HollowWorld) implement automated support for UML/OCL to XSD transformation based on such formally-specified rules.

4.4.2.4.6 Implement ShapeChange support to test/demonstrate the ability to apply formal rules (1.1.2.4.5) to create corresponding XSD-based schemas from UML/OCL-specified SWE domain models. Initial emphasis should be placed on Observation and Measurement (O&M) as the core conceptual schema, followed by SensorML and other dependent SWE schemas.

4.4.3 CCI Deliverables

The OWS-8 CCI thread requires the following types of deliverables:

- **<u>Documents</u>: Engineering Reports (ER), Information Models (IM), Encodings (EN), and Change Requests (CR)**
  These shall be prepared in accordance with OGC published templates as defined on the OGC portal. Engineering Reports shall 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. <u>All documents created in response to this program shall include "OWS-8" in the title</u>, to facilitate later literature searches.

- **<u>Implementations</u>: Services, Clients and Tools**
  Each of these shall 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 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.

Note that certain draft deliverables will be required by the due dates for Key Initial Design and/or the Interim Milestone as shown in the Master Schedule (RFQ Main Body, Section 4.6), for use in cross-thread development. These early deliverables will be designated and handled on a per-thread, per-deliverable basis.

4.4.3.1 Documents Required

The following Engineering Reports and other documents will be developed in the Observation Fusion thread and submitted to the OGC Specification Program at the completion of the OWS-8 Testbed.

Table 4-6. CCI Engineering Reports (ER), Information Models (IM), Encodings (EN), and Change Requests (CR)

Deliverable	Type
Semantic Mediation subthread	
1) <u>OWS-8 CCI Semantic Mediation</u> : Findings of the investigation about developing the Mediation Component and using ontologies for semantic mediation; description of the architecture for semantic mediation; lessons learned from implementing the mediation client; approaches for Encoding Models in RDF; rules and Mappings used and lesson learned to map community Data Models, including mapping of CRS systems.	**ER**
2) <u>OWS-8 CCI Data Model Encodings in RDF</u> Including the core model (RMM), and critical components of the NGA and USGS Data Models, mappings and rules.	**IM/EN**

3) OWS-8 CRS Encodings in RDF including mappings among CRS's.	**EN**
4) OWS-8 WFS 2.0 Change Requests as needed.	**CR**
Portrayal Services subthread	
5) OWS-8 Portrayal ER with the following: a. CSW ebRIM Profile for Portrayal Registry; Extension Points for military symbology; evaluation of the use of portrayal services and registries. b. Symbology Encoding: LTDS Symbol Encodings stored in the DGIWG Registry and Portrayal rules. c. Harmonization with OGC portrayal services; KML portrayal registries; encoding rule improvements to support fine-grained styles; feasibility of supporting the concept of layers and styles associated with layers; BalloonStyle child elements such as styles and scripts; NSG Application Schema support. ***Note: This is a possible cross-thread topic with the Aviation Thread. However, the However, the portrayal tasks in CCI thread are more experimental than is suitable for Aviation thread.***	**ER**
Schema Automation subthread	
6) OWS-8 Schema Automation: Summary of changes and update of the ShapeChange tool: summary of OCL/Schematron use for Schema development to support codelist, expressions like "let ..in" and others, and formal encoding rules for SWE-associated Schema (e.g., O&M) Automation.	**ER**

4.4.3.2 Implementations: Services, Clients, and Tools

Table 4-7. CCI Services, Clients and Tools

Deliverable	Type
Semantic Mediation subthread	
1) CCI Mediation Component: It is a component capable of: translating between instances of domain models in GML and RDF; semantic querying over a knowledge base (Common ontology + domain ontologies + rules + mappings); providing a WMS and WFS interfaces being able to retrieve results (maps and feature data) to the client in this thread. The WMS service includes an FPS interface, able to assigning styles to layers and retrieving maps; invoking queries to a Catalog via CSW for discovering services and style sets.	**Service(s)**
2) WFS 2.0 server that provides data based on the NGA Data Model (Note: NGA data will employ CRS specifications maintained in the DoD/IC Coordinate Reference Systems Dictionary).	**Service**
3) WFS 2.0 server that provides data based on the USGS Data Model	**Service**
Semantic Mediation and Portrayal Services subthreads	
4) Mediation / Portrayal clients for SLD, SE and KML. Clients capable of: requesting and consuming data through a user	**Client**

specified Data Model and; applying a symbol set such as GeoSym, MILSTD 2525, or a machine dependent symbols to the data. Clients must address the requirement detailed in the Portrayal Services Requirements, including: Advance the use of SLD documents by creating a link between a SLD document in a Get Map Request and SE from the portrayal registry CSW ebRIM interface; demonstrate if the same style resources could be used for OGC Portrayal Services and KML data; evaluate the use of portrayal registries within KML; help identify the need for extension points to support military Symbology, including MIL-DTL-89045A, GeoSym and MIL-STD-2525C, and Common Military Symbology.	
Portrayal Services subthread	
5) CSW ebRIM service interface to the DGIWG Portrayal Registry. ***Note: This is a possible cross-thread topic with all OWS-8 threads.***	**Service**
KML Portrayal subthread	
6) Feature Portrayal Service: for Symbology Encoding and KML; to support use of a URL with a fragment identifier to reference the particular Style/StyleMap element in the KML document. This can be part of the mediation component.	**Service**
Schema Automation subthread	
7) ShapeChange UML-to-GML Application Schema (UGAS) (tool) enhancements	**Tool**

4.4.4 CCI Enterprise Viewpoint

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. An example of differences in the feature type “Dam” is presented in Figure 4-22.

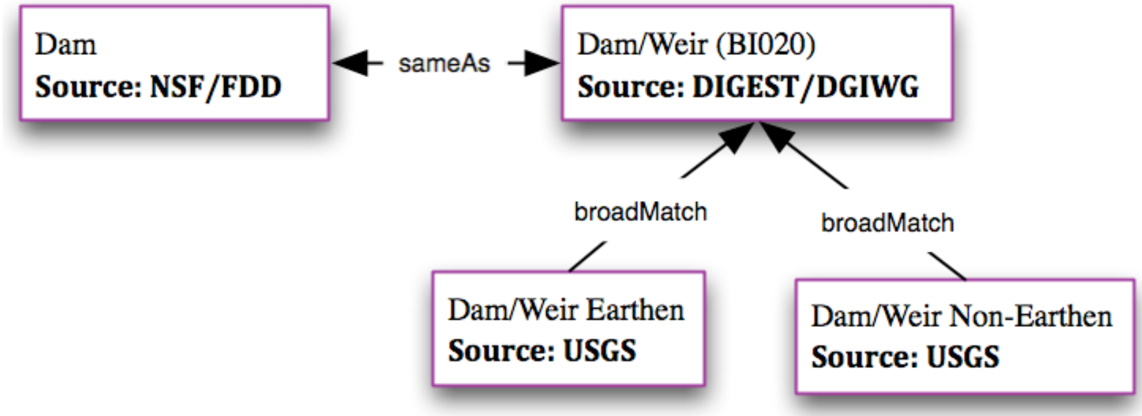


Figure 4-22. Example of the representation of the concept "Dam" in NSG, USGS and DIGEST

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.

Previous harmonization activities include the U.S. Federal Geographic Data Committee (FGDC) Framework Layers, which promoted community agreed-upon data models. In addition to taking a great deal of time, the resulting data models ended up having only those features and attributes that all stakeholders could agree to include. This leads to a situation in which no one got everything they felt important, which was an impediment to easy sharing of non-agreed-upon data. Today, the ad hoc and rapidly changing nature of data sharing makes it virtually impossible for a user to identify all of the potential sources ahead of time, not to mention take the time-consuming step of performing hundreds or thousands of one-to-one maps.

OGC demonstrated the ability to use the "lowest common denominator" approach in 2003 with the Geospatial One Stop (GOS) Transportation Pilot (GOS-TP), in which four different data models were mapped into the FGDC Framework Transportation Layer. We believe that Information Technology has matured to the point where it should now be possible to share data without prior negotiations and without losing information in the process.

Several strategies can improve interoperability among communities. These include:

- 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.
- Advance the use of semantic tools (e.g. ontologies) to facilitating harmonization and mapping of community models.

- Advance approaches to re-use of visualization artifacts among communities such as symbols available in registries that can be linked to a specific concept (i.e. featuretype).
- Improve available popular data encodings, such as KML, to represent better the domain model data, layers and symbology from different communities.

4.4.5 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.

4.4.5.1 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 and as one of the output formats used by the ShapeChange tool in the CCI schema automation subthread.

Work to be performed in this thread shall use GML version 3.2.1 unless otherwise indicated. We encourage participants in the Testbed to help advance upgrades of GML profiles to version 3.2.1 through prototyping, testing, and submission of Change Requests to the appropriate OGC Working Group.

4.4.5.2 Styled Layer Descriptor (SLD)

Relevant Specification and Documents:

- *ISO 19117:2005 – Geographic Information- Portrayal*
- *OGC 10-127r1 – OWS-7 Aviation Portrayal Engineering Report* http://portal.opengeospatial.org/files/?artifact_id=40134
- *OGC 05-078r4 and 08-064 –Styled Layer Descriptor (SLD) Profile of the Web Map Service Implementation Specification* http://portal.opengeospatial.org/files/?artifact_id=22364 with CR http://portal.opengeospatial.org/files/?artifact_id=28921&version=1
- *OGC 05-077r4 – Symbol Encoding (SE)* http://portal.opengeospatial.org/files/?artifact_id=16700
- *OGC 09-012 – OWS-6 Symbology-Encoding Harmonization ER (Note: this will be especially relevant to OWS-8 Portrayal registries development)* http://portal.opengeospatial.org/files/?artifact_id=33519
- *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
- *OGC 05-110 - Feature Portrayal Service (FPS)* http://portal.opengeospatial.org/files/?artifact_id=13186&version=2

- *OGC 07-006r1 - OGC Catalog Service Implementation Specification (CSW) 2.0.2* http://portal.opengeospatial.org/files/?artifact_id=20555

The CCI Thread of OWS-8 will build on the portrayal work from OWS-7 (in coordination with the Aviation thread) focusing on demonstrating the ability of applying different styles/symbols to the same feature data depending on the styling rules. The separation can be achieved by applying the SLD, in conjunction with the FPS and the CSW specifications, to demonstrate the potential of a scalable, flexible and interoperable architecture for producing customizable maps. 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.

4.4.5.3 KML

Relevant Specification and Documents:

- *OGC 07-147r2. KML* http://portal.opengeospatial.org/files/?artifact_id=27810
- *OGC 07-113r1 KML 2.2* Reference - An OGC Best Practice http://portal.opengeospatial.org/files/?artifact_id=23689

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.

KML encoding will be advanced to support different styles per feature type. KML encoding rules do not support different styles per feature type. A similar filtering mechanism as in SLD/SE will be explored to achieve the styling of features on the same level of granularity, using KML.

4.4.5.4 O&M

Relevant Specification and Documents:

- *07-022r1 Observations and Measurements* http://www.opengeospatial.org/standards/om

O&M defines an abstract model and an XML schema encoding for observations, and it provides support for common sampling strategies. O&M also provides a general framework for systems that deal in technical measurements in science and engineering.

The Schema Automation subthread will use the OGC Observation and Measurement (O&M) to improve the OCL rules supported by ShapeChange, transforming the UML O&M model to GML.

4.4.5.5 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 will be used in the Semantic Mediation subthread to encode the common RMM model (Rosetta Mediation Model) for portions in common among the NGA, USGS, AGC, and DSTL data models. It will also be used to encode mappings and rules. 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.

4.4.5.6 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. RIF will be investigated to perform translation between data models in the Semantic Mediation Subthread.

4.4.5.7 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).

4.4.5.8 USGS National Map Data Model

Relevant Specification and Documents:

- USGS NationalMap. 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.

4.4.5.9 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.

ISO 19139 encoding rules will be used by the ShapeChange tool to enable profiling, possibly based on the xsdDerivation UML tag concept.

4.4.5.10 OCL

Relevant Specification and Documents:

- *Object Constraint Language (OCL) V 2.2* http://www.omg.org/spec/OCL/2.2

OCL is a formal language used to describe expressions on UML models. These expressions typically specify invariant conditions that must hold for the system being modeled or queries over objects described in a model.

OCL will be used in the Schema Automation subthread by the ShapeChange tool to encode rules to create application schemas.

4.4.6 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.

4.4.6.1 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 in the CCI sub-thread.

4.4.6.2 OGC Mediation Component

This OGC Mediation component is capable of:

- Translating between instances of domain models in GML and RDF..
- Semantic querying over a knowledge base (Common ontology + domain ontologies + rules + mappings).
- Providing a WMS and WFS interfaces being able to retrieve results (maps and feature data) to the client in this thread. The WMS service includes an FPS interface, able to assigning styles to layers and retrieving maps.
- Invoking queries to a Catalog via CSW for discovering services and style sets.

The OGC Mediation Component is a new area of development and we are seeking innovative proposals.

4.4.6.3 Feature Portrayal Services

Relevant Specifications and Documents:

- *OGC 09-012 – OWS-6 Symbology-Encoding Harmonization ER (Note: this will be especially relevant to OWS-8 Portrayal registries development)* http://portal.opengeospatial.org/files/?artifact_id=33519
- *OGC 05-012r1 - Symbology Management* http://portal.opengeospatial.org/files/?artifact_id=13285
- *Feature Portrayal Service and Styled Layer Descriptor* http://www.opengeospatial.org/standards/sld
- *OGC 04-040 - Style Management Services for Emergency Mapping Symbology* http://portal.opengeospatial.org/files/?artifact_id=7470

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). 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. Figure 4-23 shows the interactions between a Feature Portrayal Service and other components.

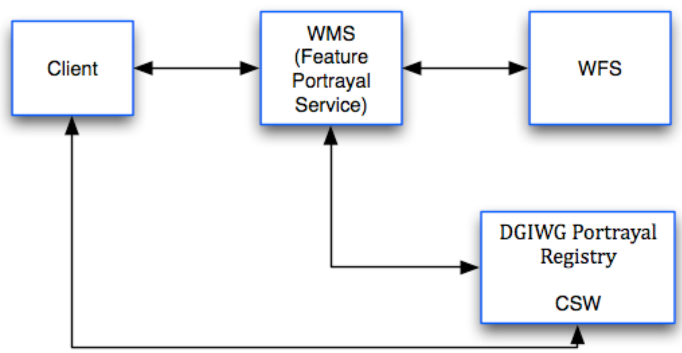


Figure 4-23. Feature Portrayal Service

The FPS is an extension of the basic WMS. The FPS WMS inherits all of the attributes from the WMS and adds support for the use of SLD 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.

In this thread the styles and symbols will be stored in a Registry (DGIWG Portrayal) and accessed via CSW to symbolize feature data using styles encoded in SLD, SE and KML. See Catalog Services section for more detail about CSW.

4.4.6.4 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.

The OWS-7 effort involved the design of a portrayal registry model, that was implemented as a set of ebRIM Classes, Associations and Classifications (within the 'Type' Classification Scheme) which where then loaded into a CSW-ebRIM registry.

The DGIWG Portrayal Registry will be used to advance a CSW ebRIM profile, advancing the use of portrayal registries for KML, SLD and SE. The DGIWG Portrayal Registry is a repository of symbols and portrayal rules that link symbols to features. SE is the standard XML encoding for these portrayal rules and symbols. The DGIWG Portrayal Registry will be able to output a SE document for rules and symbolizers for a symbol set. The requirements on a portrayal registry supporting KML data are similar to a portrayal registry supporting other OGC Portrayal Services.

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

4.4.6.5 *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 04-100 OWS-2 Application Schema Development*, 0.0.4,
- *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 theGeospatial 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.

4.4.7 Engineering Viewpoint

Figure 4-24 summarizes the main components of this thread and the process flow among them to fulfill the tasks requirements.

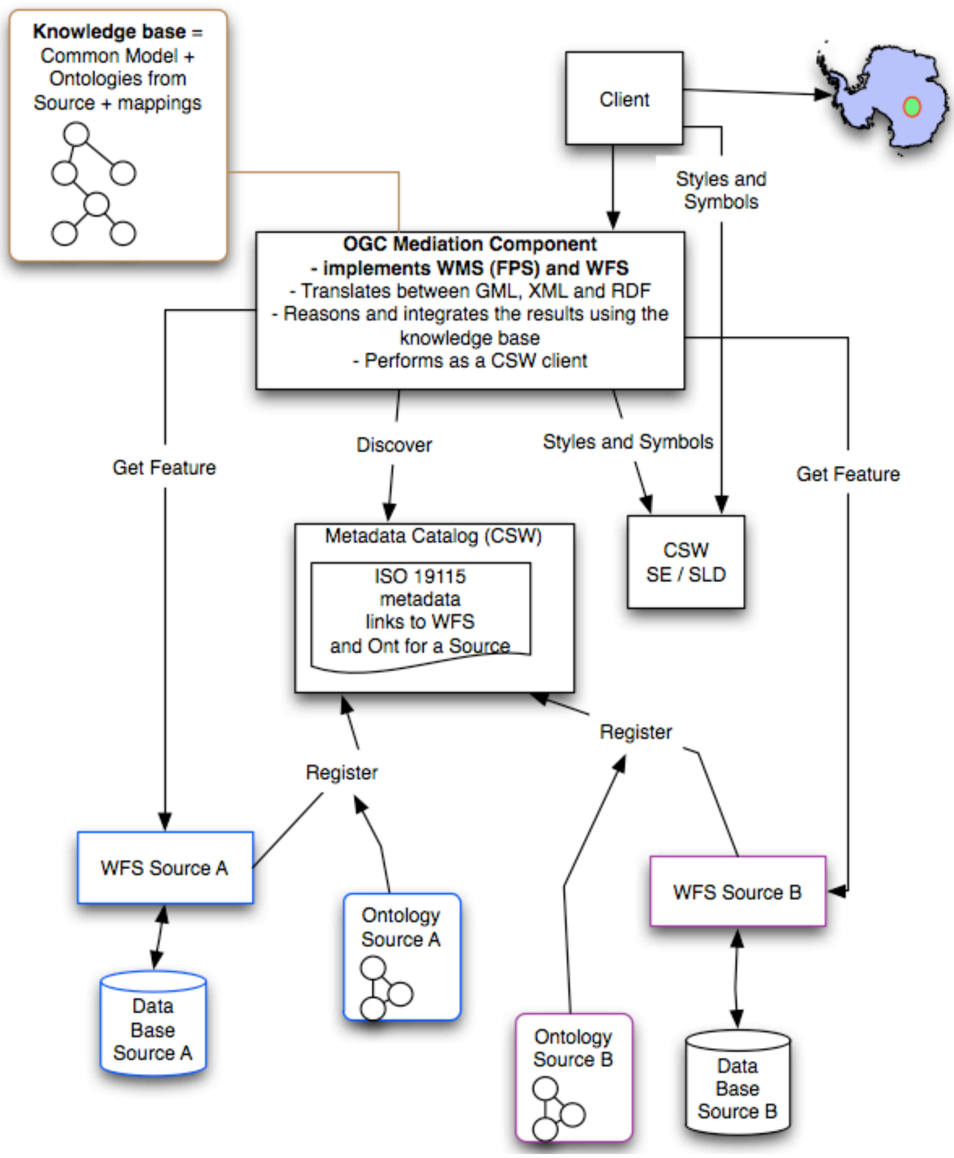


Figure 4-24.CCI Thread Engineering Viewpoint

Various WFS services, based on different data models, will be available. These services are registered in a catalog where each service is associated with a domain ontology. These WFS services will be invoked via the OGC Mediation Component. The Mediation Component not only is a WFS and CSW client, but also implements a WFS and WMS interface. The mediation component, as a CSW client, accesses a symbology registry to generate maps based on the feature type, the symbols, and rules registered for those feature types. The mediation

Component also translates between instances of domain models in GML and RDF, queries a knowledgebase and integrates the results in a map with proper styles. The knowledge base contains the common model (RMM), ontologies representing each data model, mappings, and rules.

The process is as follows:

1. A user makes a request.
2. Client transforms the user request and sends a request to the OGC Mediation Component.
3. The OGC Mediation Component translates queries into ontology queries. It previously interrogated the catalog to get information about OGC services and their corresponding ontology.
4. The OGC Mediation Component performs a semantic query to the knowledgebase.
5. Results of the semantic query provide the semantics to properly construct the queries to OGC services (WFSs from each data source).
6. The OGC Mediation Component queries each data source via WFS.
7. The results of the queries are then mapped to the common model, which is the model the client understands (GML to RDF and RDF to GML).
8. The OGC Mediation Component selects the proper styling.
9. The OGC Mediation Component responds to the client.

4.5 Aviation Thread

The Aviation Thread of OWS-8 builds on the Aeronautical Information Management (AIM) and Aviation threads of OWS-6 and OWS-7 respectively, 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.

AIXM and WXXM are developed by FAA and EUROCONTROL as global standards for the representation and exchange of aeronautical and weather information, respectively. Both models were designed as a basis for enabling the transition to a net-centric, global interoperable Air Transport System (ATS). FAA and EUROCONTROL seek to leverage the process and results of the OWS-8 Aviation Thread in their efforts to increase industry adoption of AIXM and WXXM, and to support the operational use and validation of these emerging standards. Both agencies also plan to use those standards in their System Wide Information Management (SWIM)-related components of the US NextGen and EU SESAR programs.

As with OWS-6 and OWS-7, it is expected that the results of the Aviation Thread of OWS-8 will be contributed to those programs with a focus on the applications of OGC specifications in the definition and implementation of the agencies' SWIM environments.

4.5.1 Aviation Thread Scope

In OWS-8, 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:

1. Advancement of AIXM in the areas of maturing the delivery, filtering and update of AIXM 5.1 using WFS-T/FE 2.0, continuing the development of reusable tools, benchmarking of compression techniques for enhanced performance, advancing styling and portrayal support, and validating the emerging metadata and GML profiles currently under development within the Aviation Domain Working Group (DWG),
2. Advancement of the architecture developed in OWS-6 and OWS-7 to further advance the Event Notification Architecture including support for the emerging Digital NOTAM Event Specification, use relevant concepts contained within the RTCA's SC-206 Operational Services and Environment Definition (OSED) for Aeronautical Information Services and Meteorological Data Link Services, and address the requirements for implementing an Authoritative Data Source for AIXM data,
3. Advancement of various concepts related to WXXM and weather information such as using coverages for encoding representative weather forecast and radar datasets, supporting on-demand Coordinate Reference System (CRS) specifications/transformations, exploring alternative distributed architectures for managing Units of Measure (UoM), demonstrating the applications of probabilistic Terminal Aerodrome Forecasts (TAF) decision making applications, and reviewing/validating the WXXM schemas.

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 (including digital NOTAMs, information about field conditions and relevant meteorological information).

4.5.2 Aviation Thread Requirements

The Aviation Requirements fall under three categories, described in this section according to the following outline:

4.5.2.1 Advancement of AIXM

4.5.2.1.1 Maturation of delivery, filtering and update of AIXM 5.1 using WFS/FE 2.0

4.5.2.1.2 Continued development of reusable tools

4.5.2.1.3 Benchmarking of compression and binary XML techniques

4.5.2.1.4 Interoperable styling and portrayal

4.5.2.1.5 Validation and advancement of AIXM Metadata and GML profiles

4.5.2.2 Advancement of Aviation Architecture Developed in OWS-6 and OWS-7

4.5.2.2.1 Advancement of Event Notification Architecture

4.5.2.2.2 Leveraging of existing Aviation Datalink standards, concepts and requirements

4.5.2.2.3 Support for Authoritative AIXM Data Source requirements

4.5.2.3 Advancement of WXXM and Weather Concepts

4.5.2.3.1 Review and validation of WXXM schemas

4.5.2.3.2 Recommendations for encoding representative weather forecast and radar datasets

4.5.2.3.3 Support for on-demand Coordinate Reference System transformations

4.5.2.3.4 Recommendations for distributed approach for managing UoMs

4.5.2.3.5 Integration of probabilistic information into decision making

With respect to data sources:

- Existing data sources should be used to the extent possible to test the requirements and support the thread scenarios.
- 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.
- The thread participants will have to create ad-hoc AIXM 5.1 data representing examples of digital NOTAMs as specified in the Digital NOTAM Event Specification, based on the baseline data provided by the sponsors.

4.5.2.1 Advancement of AIXM

4.5.2.1.1 Maturation of delivery, filtering and update of AIXM 5.1 using WFS/FE 2.0

References

- *OWS-6 AIM Engineering Report OGC OGC doc# 09-050r1*
  http://portal.opengeospatial.org/files/?artifact_id=34032
- *OWS-7 Aviation- AIXM Assessment Report OGC doc# 10-131r1*
  http://portal.opengeospatial.org/files/?artifact_id=40502
- *OWS-7 Aviation Architecture Engineering Report OGC doc# 10-079r3*
  http://portal.opengeospatial.org/files/?artifact_id=40133
- *Requirements for Aviation Metadata, Guidance on the Aviation Metadata Profile and GML Profiles (Draft versions & discussion papers), available on Aviation DWG public wiki*
  http://external.opengeospatial.org/twiki_public/bin/view/AviationDWG/WebHome

The Aviation Thread of OWS-8 will build on the work performed in OWS-6 and OWS-7, as documented in the OWS-6 and OWS-7 Engineering Reports listed above. More specifically, the Aviation Thread of OWS-8 will address the following requirements:

- Identify and test options for addressing the conflict (documented in the OWS-7 AIXM Assessment Report) between the AIXM temporality model and the OGC Feature Model. This activity may result in developing guidance for using AIXM over WFS 2.0, suggesting changes to WFS 2.0 and/or AIXM 5.1, or developing a WFS Aviation Profile which could be eventually endorsed by the Aviation DWG.
- Identify and test options for dealing with estimated or unknown end of validity for attribute values in AIXM 5.1 (where indeterminate equals unknown or estimated). Currently the FE 2.0 specification (based on ISO 19108 – Temporal Schema) states, "if any input value of TM_TemporalPosition is indeterminate, an exception shall be raised". This FE 2.0 behavior presents an issue when working with AIXM 5.1 data since indeterminate is heavily used in aeronautical features. Refer to OWS-6 AIM Engineering Report for more information on this issue.
- Further explore and test SNAPSHOT queries support and how they can be supported via WFS 2.0.
- Identify and test options for solving the issue of filtering AIXM events by "property" (issue identified during OWS-7). This activity may result in developing guidance for supporting the filtering of AIXM events or developing an Aviation Profile for Event Service which could eventually be endorsed by the Aviation DWG.
- Leverage WFS 2.0 capabilities, such as
  - WFS 2.0 Stored Queries: including testing of the creation, loading and deletion of Stored Queries.
  - WFS 2.0 Additional Objects: including investigating how such objects can be used as a means for simplifying xlink referencing and resolving.
- Implement (and update as needed) the GML and metadata profiles for AIXM 5.1, following the guidelines and requirements identified by the Aviation DWG.

4.5.2.1.2 Continued development of reusable tools

References

- *OWS-7 UML to Schema, Conversion and Validation ER doc# 10-137* http://portal.opengeospatial.org/files/?artifact_id=40336&version=1
- *Digital NOTAM Event Specification - Increment 1 (working draft)* http://www.eurocontrol.int/aim/gallery/content/public/events/notam_2010/Digital%20NOTAM%20Event%20Specification%200.4.pdf

The Aviation Thread of OWS-8 will build on the work performed in OWS-7, as documented in the OWS-7 Engineering Report listed above. More specifically, the Aviation Thread of OWS-8 will address the following requirements:

- Continue the development of the open source AIXM Validation tool (developed in OWS-7 to validate the output of a WFS 2.0 against AIXM 5.1 schema and Schmetaron business rules), more specifically to
  - Implement, using ISO Schematron, the business rules specified in the Digital NOTAM Event Specification for each specific scenario. This activity also includes providing recommendations to complement the existing business rules when necessary (minimal data requirements, consistency rules, data plausibility, etc).
  - Supporting Authoritative AIXM Data Source use case (section 4.5.2.2.3) in conjunction with the WFS to enable checking and validation of data changes (submitted via WFS-T 2.0) before they are committed to the database.
- Continue the development of the UML to AIXM open source tool (developed in OWS-7 using FullMoon to validate the AIXM model and convert it to XML schema), more specifically to
  - Address the recommendations captured in the Engineering Report to ensure that AIXM is compliant with mainstream modeling tools and fully compliant with the Application Schema Specification ISO 19103. This activity may include repackaging the AIXM 5.1 UML model to make its structure compliant with the ISO 19103 requirements.

4.5.2.1.3 Benchmarking of compression and binary XML techniques

References

- *Efficient XML Report by NNEW* https://wiki.ucar.edu/download/attachments/23364539/EfficientXMLReport_v1+0.doc?version=1&modificationDate=1271765646000
- *W3C EXI* http://www.w3.org/XML/EXI/
- *Sun Fast Infoset* http://java.sun.com/developer/technicalArticles/xml/fastinfoset/
- *Binary XML* http://portal.opengeospatial.org/files/?artifact_id=13636

As AIXM becomes the standard format for exchanging aeronautical information, it becomes essential to look at the efficiency cost and alternatives for this XML-based format in the Aviation domain. The Aviation Thread of OWS-8 will investigate and benchmark binary XML and compression technologies that can be applied to AIXM (delivered over WFS).

Options to be considered may include but are not restricted to the W3C EXI (using/adapting the W3C EXI Test Framework), Sun Fast Infoset, Binary XML, and GZIP. Options recommended should, at a minimum,

- Consider GML/AIXM-specific characteristics (such as dealing with large number of coordinates, and taking into account the local nature of most AIXM coordinates)
    - For instance, when multiple coordinates occur (in a linestring or polygon) in an AIXM message, the coordinates can refer to a local (base) coordinate and the compression/binary technique can then only generate/encode the deltas for the other coordinates.
- Be open standards, cross-platform, efficient, and lossless.
- Have minimal impacts on developers and users.

Criteria to be considered in the investigation and benchmarking of results include, at a minimum,

- The impact on performance of parsing, processing overhead and memory requirements,
- Size and compactness of data,
- Availability of tools to support the compression/processing of data,
- Any tradeoffs between usability and efficiency,
- Complexity of data (as in depth/nesting of elements and attributes, etc).

4.5.2.1.4 Interoperable styling and portrayal

References

- *OWS-7 Engineering Report – Aviation Portrayal doc # 10-127r1* http://portal.opengeospatial.org/files/?artifact_id=40134

The Aviation Thread of OWS-8 will build on the portrayal (including symbol and style management) architecture developed in OWS-7, and continue to explore the portrayal of AIXM 5.1 and WXXM 1.1 to advance the interoperable visualization of aeronautical and meteorological information. In particular, the Aviation Thread of OWS-8 will focus on:

- Advancing the architecture developed in OWS-7 to support multiple style development for AIXM and WXXM data, style selection linked to modeled user needs, and other recommendations from the OWS-7 Aviation Portrayal ER.
- Drafting potential International Civil Aviation Organization (ICAO)[7] guidelines for SLD and symbol libraries based on ICAO Annexes 3 and 4. ICAO Annex 3 “Meteorological Service for International Air Navigation” (symbols for significant weather, front and convergence zones, etc) and ICAO Annex 4 “Aeronautical Charts” (aerodrome symbols for approach charts, symbols for radio navigation aids, obstacles, etc) specify the graphical symbols to be used when producing in-flight documentation, charts, etc.

[7] http://www.icao.int/. ICAO is a specialized agency of the United Nations with the mandate to ensure the safe, efficient and orderly evolution of international civil aviation.

  - This requirement stems from the need to advance the existing lists of symbols required by ICAO and enable the transition from the historically defined symbols used in paper charts. The ultimate goal is to establish improved symbol libraries and guidance satisfying the requirements for the display of digital data, as part of the current transition from the Aeronautical Information Systems (AIS) concept to the Aeronautical Information Management (AIM) paradigm.

This requirement will be coordinated with the Feature Decision Fusion (FDF) portrayal requirement (section TBD).

4.5.2.1.5 Validation and advancement of AIXM Metadata and GML profiles

References

- *Requirements for Aviation Metadata and Guidance on the Aviation Metadata Profile – OGC Aviation Domain Working Group (DWG) public wiki page* http://external.opengeospatial.org/twiki_public/bin/view/AviationDWG/WebHome
- *GML profile for AIXM 5.1*
- *OGC Aviation Domain Working Group (DWG) public wiki page* http://external.opengeospatial.org/twiki_public/bin/view/AviationDWG/WebHome

The Aviation Thread of OWS-8 shall implement and test Metadata and GML profiles for AIXM 5.1 that conform to the requirements and guidance laid down by the Aviation DWG. With regard to metadata, OWS-8 will use (and advance if needed) the documents “Requirements for Aviation Metadata” and “Guidance on the Aviation Metadata Profile” issued by the Aviation DWG, whose objectives are 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.

More specifically, the Aviation Thread of OWS-8 will

- Implement and test the AIXM 5.1 metadata profile (schema) in the WFSs and client applications used in the Aviation Thread. The profile shall be an ISO 19139 metadata profile for AIXM encompassing all the Aviation metadata requirements identified by the Aviation DWG.
- Test and validate this AIXM 5.1 metadata profile by exchanging over WFS-T AIXM 5.1 data carrying metadata information (also refer to section 4.5.2.2.3), addressing at least the following two use cases
  - Metadata information is directly included in the AIXM dataset
  - Metadata information is provided in a separate file
- Implement and test the AIXM 5.1 GML 3.2 profile (and associated schema) in the WFSs and client applications used in the Aviation Thread. The GML profile consists of a selection of GML features that all AIXM implementers need to eventually support. Resources used to create the current draft profile include the simple feature profile by OGC, EAD document for current static data (Europe), AMDB requirements and Airport GIS database requirements (FAA).

4.5.2.2 Advancement of Aviation Architecture Developed in OWS-6 and OWS-7

4.5.2.2.1 Advancement of Event Notification Architecture

References

- *OWS-7 Aviation Architecture Engineering Report doc #10-079r3*
  http://portal.opengeospatial.org/files/?artifact_id=40133
- *OWS-7 Event Architecture Engineering Report doc # 10-060r1*
  http://portal.opengeospatial.org/files/?artifact_id=39509
- *Digital NOTAM Event Specification - Increment 1 (working draft)*
  http://www.eurocontrol.int/aim/gallery/content/public/events/notam_2010/Digital%20NOTAM%20Event%20Specification%200.4.pdf

The Aviation Thread of OWS-8 will build on the Event Architecture developed in OWS-6 and OWS-7, with a focus on

- **Advancing the architecture to support additional features, such as**
  - Supporting multiple sources of events and data changes, and multiple types of aeronautical events and data changes,
  - Validating and enhancing the Event Schema from the emerging Digital NOTAM Event Specification (see next section), and investigating the use of GML's dynamicFeatureCollection and dynamicProperties in the representation of AIXM Messages (to encode the time-varying properties),
  - Demonstrating the use of the WFS-T for posting AIXM events to the AIXM database,
  - Investigating the support of different delivery protocols (push/pull), including but not limited to
    - Investigating Atom/AtomPub, and WS-Eventing, broadcasting of events/notifications,
    - Supporting the broadcasting of event/notifications within a specific geographic area to all users regardless of subscriptions (e.g. TFR Temporary Flight Restriction being erected in an area in the case of disaster recovery, avoidance operations or national security operations),
    - Supporting the transmission of events at pre-defined intervals (e.g. for Weather data), and/or supporting batch transmission of events.
  - Enhancing registration & subscription lifecycle management by supporting features including but not limited to
    - Improving the accuracy of subscription filters,
    - Exploring the use of dynamic spatial filters (dependent on aircraft position),

        - Exploring rules for automatically terminating or renewing subscriptions (e.g. when a flight is delayed or an airport is no longer relevant to a flight),
        - Leveraging the Stored Queries concept (from WFS) (e.g. associating a standard set of elements/subscriptions relevant to a flight that the user/application automatically subscribes to upon filing the associated flight plan).
        - Exploring the concept of Event Channels (Events related to specific airports or geographic regions)
            - Exploring the concept of ad-hoc channels to better support dispatcher-client common operating picture (as in when a dispatcher adds a subscription, the pilot receives that addition and vice versa)
            - Defining best practices for defining Aviation Event Channels and the publication/subscription to these channels, including considering classification schemes for event channels and even types.

- **Validating and advancing the emerging Digital NOTAM Event Specification**

  The Digital NOTAM Event Specification is being developed by a small focus group composed of operational and technical experts from EUROCONTROL, FAA, ANSP, airlines and industry. It defines the rules for harmonized encoding (in AIXM 5.1) 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.

  The Aviation Thread of OWS-8 will contribute on the validation and advancement of this emerging specification by

    - Using, testing and advancing the AIXM Event Schema (as a container for Digital NOTAMs). This schema is provided as an extension to the core AIXM 5.1 and is designed as a container for Digital NOTAM. In particular, the schema enables the association of digital AIXM encodings of the events with the classical text NOTAM, as well as enables the storage and unique identification of the events.
    - Demonstrating how Digital NOTAM events can be stored, queried, filtered and retrieved in an OGC Web services environment, and providing recommendations to improve the Event Specification.
    - Implementing and testing the scenarios described in the Event Specification, including:
        - Creating digital AIXM 5.1 datasets representing the different scenarios, in compliance with the guidance defined in the Specification.
        - Testing the query, filtering and display of the corresponding digital datasets via WFS.

- Implementing in ISO Schematron the business rules defined in the Event Specification for each specific scenario (see requirement 4.5.2.1.2) to be used for the validation of WFS output using reusable open source tools.

4.5.2.2.2 Leveraging of existing Aviation Datalink standards, concepts and requirements

References

- *Radio Technical Commission for Aeronautics (RTCA[8]) SC-206 Aeronautical Information Services (AIS) Data Link* http://www.rtca.org/comm/Committee.cfm?id=58
- *Radio Technical Commission for Aeronautics (RTCA) DO-308* http://www.rtca.org/downloads/ListofAvailableDocsSept2010.htm#_Toc273956283
- *Radio Technical Commission for Aeronautics (RTCA) DO-178B* http://www.rtca.org/downloads/ListofAvailableDocsSept2010.htm#_Toc273956437
- *Radio Technical Commission for Aeronautics (RTCA) DO-278* http://www.rtca.org/downloads/ListofAvailableDocsSept2010.htm#_Toc273956319
- *Radio Technical Commission for Aeronautics (RTCA) DO-160F* http://www.rtca.org/downloads/ListofAvailableDocsSept2010.htm#_Toc273956453

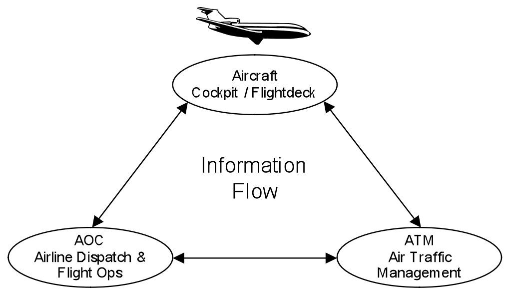
The Aviation Thread of OWS-8 will explore and recommend ways to begin leveraging and supporting the emerging Data Link concept as defined by the RTCA SC-206. Such ways include exploring ways to use

- The concepts contained within RTCA's SC-206 DO-308 Operational Services and Environment Definition (OSED) for Aeronautical Informational Services (AIS) and Meteorological (MET) Data Link Services.
  - Incorporating SC-206's requirements from the SPR if appropriate, based on timing availability of the document release and OWS-8.
- The RTCA's SC-167 DO-178B Software Considerations in Airborne Systems and Equipment Certification.
- The RTCA's SC-190 DO-278 Guidelines for Communications, Navigation, Surveillance, and Air Traffic Management (CNS/ATM) Systems Software Integrity Assurance.
- The RTCA's SC-135 DO-160F Environmental Conditions and Test Procedures for Airborne Equipment.

As a quick background, it all starts with the consensus that the availability of timely, accurate, quality-assured and relevant aeronautical information in the cockpit is critical to the safe conduct of flight and forms the basis of aeronautical decision-making. The same is true for the ability to create a truly temporal aeronautical information environment as an essential component of the future ATM system. The data link of aeronautical information directly into the cockpit, irrespective of the aircraft's location, constitutes a notable advantage over current practices. It is assumed that this data will be continuously updated and maintained by ground-based systems and will be made available for use by the aviation community, on

[8] RTCA is a private, not-for-profit corporation that develops consensus-based recommendations regarding communications, navigation, surveillance, and air traffic management (CNS/ATM) system issues. RTCA functions as a Federal Advisory Committee and its recommendations are used by the FAA as the basis for policy, program and regulatory decisions.

the ground, and in the air by all onboard data systems. The ultimate vision and goal of the aviation community is the real-time update of aeronautical data by data link.



The Aviation architecture and technologies developed and tested in the OWS testbeds based on OGC web services, international standards and support for AIXM/WXXM are certainly aligned with that vision of supporting real-time access to and update of aeronautical data. The Aviation Thread of OWS-8 will explore ways to integrate/leverage the OWS Aviation architecture and technologies in a datalink environment. For instance, AIXM encoding of aeronautical information updates permits the use of a digitally expressed set of rules to automatically select updates that should be uplinked to the aircraft; on the basis of availability and bandwidth of data links, relevance of the update to particular flights, urgency of updates, etc.

The data link concept is described in detail in the RTCA Operational Services and Environment Definition (OSED). The OSED document presents the data link services that are envisaged to be implemented within the next decade in both the USA and Europe, and includes service descriptions for the two major categories of Aeronautical Information Management (AIM) information: AIS and MET information.

The OSED describes the intended AIS and MET data link services and the assumptions about the environment in which they operate. Derived from a network of databases on the ground and in the air, such data link service(s) will facilitate the creation of a common picture of the airspace situation for all pilots and controllers. Change notifications and timely warnings and alerts of operational hazards to the safe and efficient conduct of flight will be enabled by these data link service(s). AIS/MET data link will enable the sharing of data between aircraft and ground. This will permit adequate contract negotiations of 4D trajectories as targeted by the SESAR and NextGen initiatives.

4.5.2.2.3 Support for Authoritative AIXM Data Source requirements

References

- *ISO/IEC FDIS 19142: Geographic information - Web Feature Service, 2010-04-26,* OGC document #09-025r1, http://www.opengeospatial.org/standards/wfs
- *AIXM 5.1* http://www.aixm.aero
- *Requirements for Aviation Metadata and Guidance on the Aviation Metadata Profile – OGC Aviation Domain Working Group (DWG) public wiki page* http://external.opengeospatial.org/twiki_public/bin/view/AviationDWG/WebHome

- *OWS-6 Security Engineering Report OGC 09-035* http://portal.opengeospatial.org/files/?artifact_id=35461
- *OGC 10-192 Authentication Interoperability Experiment (IE) Engineering Report*
- *OGC 10-069r2 OWS-7 GeoSynchronization Service* - http://portal.opengeospatial.org/files/?artifact_id=39476

To date, the focus of the Aviation Threads of the OWS initiatives has been on the retrieval and querying of AIXM information via the WFS. OWS-8 will explore how the WFS-T (along with basic security and access control measures) can be used to update or insert new AIXM information back into the underlying database, while ensuring the integrity of the database as an Authoritative Data Source for AIXM (an official or recognized data source publishing reliable and accurate data for subsequent use by users).

The scope for this Authoritative Data Source requirement is limited to the following areas in OWS-8:

- **WFS and AIXM:** One WFS-T serving AIXM 5.1 (in practice, the underlying data source may be the functional combination of multiple or separate data sources)
    - The WFS-T should be able to support the update of an existing AIXM feature (by adding a timeslice to the feature) and the insertion of new features.
- **Metadata:** The requirement involves capturing the metadata associated with every WFS-T transaction. Metadata is an essential part of this process since it serves as an audit trail on the authority of the data and can be used by users to determine the usability of the data for their purposes.
    - At a minimum, the metadata should include the timestamp of the transaction, and information about the originator of the new data, their role and their organization.
- **Authentication/Authorization:** The requirement involves ensuring that the data is only being updated by the authorized sources for that type of data (e.g. only DoD, as the authorized source for SUA data, can update/insert an SUA feature), keeping in mind that the granularity of the data update constraints can be at the attribute level of features (e.g. both SUA and Class airspaces are airspace features, but they come from different authorized sources), or based on the type of timeslice (e.g. some users can only insert temp deltas when others can also insert baseline information), or limited by other geographic rules or lines of authority (e.g. some users can only submit information related to features within their facilities). The specific list of constraints will be discussed during the kickoff.
    - Note that, with respect to user authentication and authorization, the focus is NOT on the development or advancement of a security architecture. The process should identify and apply basic security measures as needed to support the authentication and authorization components of the Authoritative Data Source. Some options are presented in the OWS-6 Security ER and the Authentication IE ER.
- **Data integrity and validation:** The requirement involves validating data before it is committed to the database, according to the AIXM 5.1 business rules (possibly using the AIXM validation tool described in section 4.5.2.1.2) and other rules as needed to

ensure the integrity of the data (e.g. the scheduled level of a SUA is within the SUA boundaries, etc)

- Note that the assumption here is that the data has already been through the appropriate workflows for approval, hence the adjudication process of the data is out of scope.

- **Minimal emphasis on client functionality:** The emphasis of this requirement is on using the WFS-T along with basic security/access control measures and basic business rules to support an Authoritative Data Source for AIXM. The emphasis on further client development is minimal, and doesn't involve developing new client features (e.g. visual editing/update of the features, input forms for metadata, etc.).

4.5.2.3 Advancement of WXXM and Weather Concepts

4.5.2.3.1 Review and validation of WXXM schemas

References

- *Weather Exchange Information Model WXXM* http://www.eurocontrol.int/aim/public/standard_page/met_wie.html
- *GML 3.2* http://www.opengeospatial.org/standards/gml
- *OGC 10-132 OWS-7 WXXM Assessment Engineering Report* http://portal.opengeospatial.org/files/?artifact_id=40149

The Aviation Thread of OWS-8 involves reviewing the latest WXXM schemas for compliance with GML application schema rules. The identification of and use of existing validation tools is highly encouraged in the process.

4.5.2.3.2 Recommendations for encoding representative weather forecast and radar datasets

References

- *OGC Web Coverage Service specification v 2.0* http://www.opengeospatial.org/standards/wcs
- *GML 3.2* http://www.opengeospatial.org/standards/gml
- *Weather Exchange Information Model WXXM* http://www.eurocontrol.int/aim/public/standard_page/met_wie.html

The Aviation Thread of OWS-8 involves exploring how to best represent forecast model runs, radar representations, and other types of data that the weather community considers as being more than 4-Dimensinonal. The two types of data that OWS-8 will focus on are:

- Forecast model runs: Forecast model runs incorporate the x,y,z spatial dimensions as well as a valid time (4-D) and forecast time (5-D). The requirement is to identify a way to encode a series of forecast model runs as a single coverage, that can be served via a WCS capable in turn of supporting queries such as finding the "best" data for a specific valid time or retrieve a specific run-time/valid time combination.

- Radar data: Radar data is sometimes represented in more than 4D representation, such as when multiple radars make observations at the same physical point. The requirement is to recommend ways for representing such 5D data as a WCS coverage. One of the sources of the weather radar data that will be used in OWS-8 will be supplied by a major airline and will need to be ingested and converted to WXXM 1.1.

The main issue in dealing with the above types of data has been that the ISO coverage model specifically restricts coverages to 4D (1-3 spatial dimensions and 0-1 time dimension). The Aviation Thread of OWS-8 will explore alternatives for overcoming this restriction, and representing >4D coverages that can be served and queried via WCS. Such alternatives may include but are not restricted to including the extra "dimensions" in the Range, extending WCS to describe this information, or borrowing concepts from the Sensor Web Enablement standards that deal heavily with multiple observations over time.

4.5.2.3.3 Support for on-demand Coordinate Reference System transformations

References

- *OGC Web Coverage Service specification v 2.0* http://www.opengeospatial.org/standards/wcs
- *Weather Exchange Information Model WXXM* http://www.eurocontrol.int/aim/public/standard_page/met_wie.html

The Aviation Thread of OWS-8 will explore ways to address the following two issues:

- How can a WCS client request a specific Coordinate Reference System (CRS) (including projection, projection parameters, datum, etc) when there's no existing EPSG (or other) code associated with the CRS? How can such CRSs be encoded in this case (well-known text, GML, etc)?
- Can a WCS 2.0 server formally advertise the capability to support arbitrary CRSs (as opposed to a fixed number of possible CRSs), as specified in the client query?

As a background, in the weather domain, the set of projected spaces of interest to clients is potentially infinite. For example, a data set available in a Lambert Conformal projection (with a certain projection origin and other parameterizations) may be requested by a client in Lambert Azimuthal Equal Area projection with a completely different origin and other parameterization. EPSG codes have been insufficient to describe the combinations of projections and projection parameters that the clients may ask for.

From the WCS server perspective, the requirement becomes that of supporting an infinite number of actual CRSs on-demand, and to be able to advertise such capability in their capabilities statement. Note the focus here is on solutions based on the WCS standard and not on the Web Processing Service (WPS), which could also be used to support custom CRS conversions.

4.5.2.3.4 Recommendations for distributed approach for managing UoMs

References

- *GML 3.2* http://www.opengeospatial.org/standards/gml
- *Weather Exchange Information Model WXXM* http://www.eurocontrol.int/aim/public/standard_page/met_wie.html

The Aviation Thread of OWS-8 will explore alternative approaches for supporting distributed Unit of Measurement (UoM) definition. This requirement is motivated by two trends:

- While it may be efficient to have all units centrally (and formally) defined, there will always be times when certain organizations producing WXXM data need to define their own (new) units.

- While the majority of units are traditionally defined by major stakeholders (such as the FAA and the National Weather Service NWS), various research groups (such as the National Center for Atmospheric Research NCAR) often need to define their own new units.

One of the alternatives that have been considered to-date is to adopt an approach used by the DoD, whereby the slowly-changing/established units are specified as http URLs (e.g. http://faa.gov/uom/distance/m or http://weather.noaa.gov/uom/pressure/mb). Any unit definitions not available on the network (either new units, or organization-specific units) are then formally defined as a GML dictionary in each WXXM document that is exchanged.

The Aviation Thread of OWS-8 will explore sustainable, extensible and simple to maintain and use alternatives for the distributed definition of UoMs, keeping in mind that new units of measures will likely depend on existing units of measures.

4.5.2.3.5 Integration of probabilistic information into decision making

References

- *Weather Exchange Information Model WXXM*
  http://www.eurocontrol.int/aim/public/standard_page/met_wie.html
- *Localized Aviation MOS Program (LAMP)*
  http://www.nws.noaa.gov/mdl/lamp/lamp_info.shtml

The Aviation Thread of OWS-8 will demonstrate the potential of using probabilistic information in WXXM data to support decision-making applications, with a focus on exploring visualization and alert opportunities in client applications as this new information is available to them for the first time. Probabilistic forecasts include probability of freezing precipitation, thunderstorms, IFR conditions due to ceilings and visibilities, etc.

In addition to probabilistic guidance of weather elements, guidance Terminal Aerodrome Forecasts (TAF) are derived from these data using an algorithm developed by the Meteorological Development Laboratory (MDL) at NOAA. LAMP (the Localized Aviation Model Output Statistics (MOS) Program) is a statistical system that provides forecast guidance for sensible weather elements by using the most recent surface observations, output from simple models, and MOS guidance based on the Global Forecast System. LAMP uses surface observations, radar, lightning data, simple advective models and the latest GFS MOS outputs to create a 25-hour forecast at hourly resolution. In addition to producing best category forecasts of categorical elements, such as ceiling heights and visibility, the probability of occurrence of the individual categories is available as well. From these hourly forecasts of weather elements, an automated TAF is generated.

Incorporating these TAFs and corresponding probabilistic data is currently being tested in WXXM 1.1 and will be fully incorporated in WXXM 2.0. The Aviation Thread of OWS-8 will explore ways to query, use, and visualize this information (as retrieved from a WFS), which is available to users for the first time in Aviation Clients.

4.5.3 Aviation Thread Deliverables

The OWS-8 Aviation thread requires two types of deliverables

- <u>**Documents**</u> **- Engineering Reports (ER), Information Models (IM), Encodings (EN), Change Requests (CR):** will be prepared in accordance with OGC published templates as defined on the OGC portal. 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 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, unless it is classified as a Reusable AIXM Handling Component/Tool deliverable (Deliverable 8 in Section 4.5.3.2).

4.5.3.1 Engineering Reports (ER), Information Models (IM), Encodings (EN), Change Requests (CR) and other documents

The following Documents will be developed in the Aviation thread and may be submitted to the OGC Specification Program at the completion of the OWS-8 Testbed. All documents created in response to this program will include "OWS-8" in the title, to facilitate later literature searches.

Table 4-8. Aviation Engineering Reports (ER), Information Models (IM), Encodings (EN), Change Requests (CR)

	Deliverable	Type
1)	OWS-8 Aviation Architecture ER covering the detailed technical architecture (including Event Notification architecture, Authoritative AIXM Data Source architecture, Datalink recommendations) and final Aviation scenarios and use cases. ***Note: The event architecture is a possible cross-thread topic with the Gsync thread and the Observation Fusion – Moving Object tracking and notification service.***	ER
2)	OWS-8 AIXM 5.1 metadata refinement and recommendations ER	ER
3)	OWS-8 AIXM Performance Assessment report on compression and binary encodings performance assessment and benchmarking. ***Note: This is a possible cross-thread topic with the Gsync bulk data compression evaluation.***	ER
4)	OWS-8 ICAO guidance for SLD ER, including symbol libraries based on ICAO Annexes 3 and 4. ***Note: This is a possible cross-thread topic with the CCI Semantic thread***	ER/EN
5)	OWS-8 Report on Digital NOTAM Event Specification with recommendations and associated Schematron business rules	ER/EN
6)	OWS-8 WXXM and Weather Findings ER, covering coverage recommendations for encoding representative weather forecast datasets, CRS conversion alternatives, distributed UoM management architecture recommendations, WXXM validation	ER/IM/EN

	results and results of using probabilistic TAF data in decision-support applications	
7)	Change requests/recommendations for extensions and adaptations, as needed, to a) AIXM 5.1 (including ISO 19139 metadata schema) b) WXXM 1.1 c) GML profile for AIXM 5.1 d) OGC Web Services (such as WFS, WCS, Filter Encoding, Event Service, etc) e) Digital NOTAM Event Specification and AIXM Event Schema	CR/IM/EN
8)	AIXM 5.1 datasets for Digital NOTAM Events (EN) corresponding to specified scenarios (Note: sponsor will provide primary AIXM datasets; this is just the Digital NOTAM events data)	Data

4.5.3.2 Implementations: Services, Clients and Tools

Implementations of the following 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 following services, clients and tools may be invoked for cross-thread scenarios for OWS-8 demonstration events (Note that Deliverable 8 Reusable AIXM Handling Components/Tools will be delivered as executable or source code depending on the software license for reuse beyond OWS-8).

Table 4-9. Aviation Services, Clients, Tools

	Deliverable	Type
1)	AIXM 5.1 WFS-T 2.0 with Filter Encoding FE 2.0 Support (2 instances) to serve AIXM 5.1 data (including implementation of the AIXM metadata and GML profiles), support the posting of events to the AIXM datastore, support the Authoritative AIXM Data Source requirements, and support compression/binary GML experimentation and benchmarking. ***Note: This is a possible cross-thread topic with the Gsync bulk data compression evaluation.***	Service
2)	Authentication (PDP), Authorization (PIP), and Gatekeeper (PEP) Services (1 instance of each **as needed)** to support the Authoritative AIXM Data Source requirements	Service
3)	WXXM 1.1 WCS 2.0 (2 instances) to serve WXXM 1.1 data, and support on-demand CRS conversion. At least one of the WCS 2.0 should be able to securely ingest weather radar data supplied by a major airline and convert it to WXXM 1.1	Service
4)	Feature Portrayal Service (FPS) for AIXM, WXXM (2 instances)	Service
5)	Event Service (2 or more instances; stand-alone or as OWS extension) to satisfy the Event Notification requirements. ***Note: The event architecture is a possible cross-thread topic with the Gsync thread and the Observation Fusion – Moving Object tracking and notification service.***	Service
6)	Registry Service for symbols, styles, code lists and/or UoMs for AIXM and WXXM ***Note: This is a possible cross-thread topic with the CCI Portrayal subthread***	Service
7)	Aviation Client (2 instances) representing EFB Class 2 and/or Class 3 applications and/or hand-held electronic display device components as well as Dispatch	Client

applications, to support a) OGC Web Services described above (WFS-T, WCS, WMS, FPS, Event Architecture and/or CSW) and Authentication/Authorization services to retrieve, integrate and portray aeronautical and weather information (including probabilistic TAFs and demonstration of increased situational awareness) and events affecting certain designated areas within given time intervals meeting certain user-defined filters b) One or more Aviation Thread scenario	
8) AIXM handling components/tools and associated documentation for validating, parsing and converting AIXM data and for generating/mapping AIXM/EXI schemas including the Digital NOTAM Event Specification (One or more reusable tools, preferably open-source)	Tool

4.5.4 Aviation Thread 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 4-25), the Aviation industry is working on a framework built extensively on standards, digital data exchange and process automation.

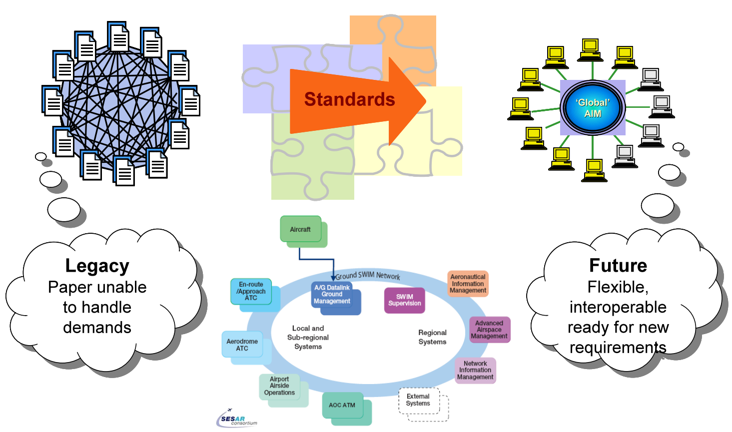


Figure 4-25. Towards a New Aeronautical Information Management Paradigm

At the heart of this new AIM paradigm is the Aeronautical Information Exchange Model (AIXM) (Figure 4-26). 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 4-27).

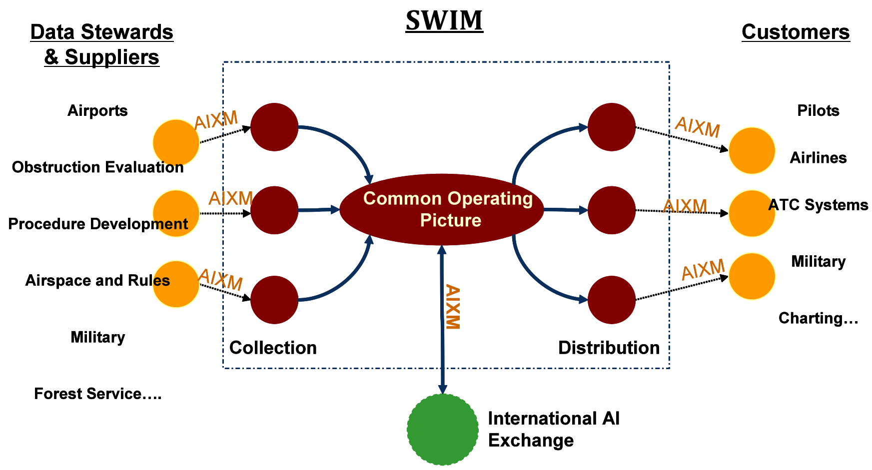


Figure 4-26. AIXM in Support of New AIM Paradigm

Figure 4-27. 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.

4.5.4.1 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 4-28). 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.

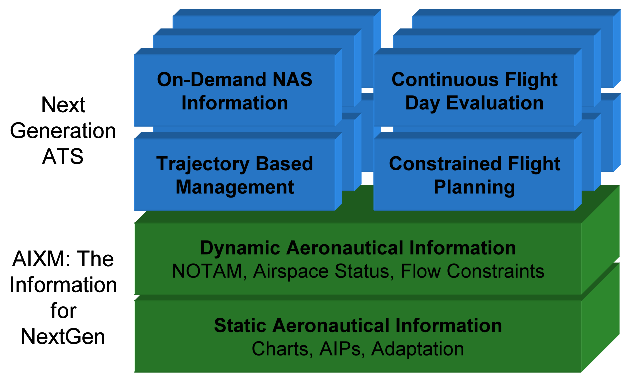


Figure 4-28. AIXM as the Foundation for NextGen

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/NNEW+Dissemination+home+page.

4.5.4.2 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 4-29) 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 4-29. 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 4.5.4.3). 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.

4.5.4.3 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 (http://www.eurocontrol.int/aim/public/standard_page/wp8.html). 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 (http://www.eurocontrol.int/aim/public/standard_page/wp14.html). 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.

4.5.4.4 Aviation Thread Scenario(s)

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-8, 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-8. This includes exercising a variety of web services utilizing AIXM and WXXM encodings (including digital NOTAMs, information about field conditions and relevant meteorological information).

Within the OWS-8 Aviation thread, the scenarios will revolve around the following themes

- Continued support for dispatch and planning activities started in OWS-7,
- Validation of the Authoritative Data Source architecture,
- Validation of the Digital NOTAM Event Specification,
- Demonstration of the use probabilistic information in weather data in Decision-making applications.

The scenarios are subject to change as determined by various factors, most notably availability of AIXM and weather data. The details and scope of the scenarios will be discussed at the initiative kickoff.

4.5.4.4.1 General Dispatch and Planning

The dispatch and planning scenario(s) of OWS-8 will build on the ones developed, refined and exercised in OWS-7 (section 4.4.8 in OWS-7 RFQ Annex B http://portal.opengeospatial.org/files/?artifact_id=36132). The OWS-7 Aviation Thread demonstrated the use of OGC Web Services to applications that support flight dispatch operations.

Highlights of OWS-7 Dispatch and Planning Scenario Description

Flight Dispatchers or Flight Operations Officers (ICAO recognizes the two terms interchangeably) are an airline's main liaison to its cockpit crews. In the United States flight dispatchers are the persons authorized by the appropriate authorities or airlines to exercise operational control, flight planning, and in-flight assistance (flight following) for commercial flights operated within U.S airspace. Flight dispatch operational functions, which are also performed for commercial general aviation operations, include estimating the effects of weather, airspace restrictions, and the availability of navigation aids and equipment upon the proposed flight. Other factors such as the aircraft's technical condition and performance, the selection of alternate airport(s), airport runway lengths and facilities, fuel uplift needs etc are taken into account when planning a flight. In Europe the flight operations officer also executes slot coordination between actual flights and the EUROCONTROL Central Flow Management Unit in Brussels.

The OWS-7 Aviation scenarios were developed to demonstrate the use of OGC web services in providing flight dispatchers and pilots with an alternative source for much of the information that is needed in the flight planning, pre-flight briefing and flight following processes. The underlying transmission methods for web services were assumed to exist. Participants in these processes are flight crew, ground controllers, custodians and providers of aeronautical information (and information updates), and custodians and providers of weather information. The role of ATC was de-emphasized in the scenarios, but it may be assumed that all in-flight operations are carried out in concert with ATC authorities.

Web services were used to deliver aeronautical information encoded in AIXM and weather information encoded in WXXM to flight dispatcher workstations and pilots portable devices. The flight dispatcher retrieves aeronautical data and weather data pertinent to the planned routes of proposed flights when preparing flight-briefing packages. Shortly prior to a flight or when the pilot is at the departure gate or in the cockpit, the pilot could download the flight-briefing package to his Electronic Flight Bag (EFB) using web services. The pilot could also use web services enabled in his EFB to update the aeronautical and weather information in the briefing package or to obtain additional information, e.g. about features that are not covered or are in-sufficiently covered in the briefing.

Additional functionality to be explored in OWS-8

Based on the requirements, the OWS-7 Dispatch and Planning scenarios will be enhanced to support additional functionality, including but not limited to

- Having aircraft and crew profiles stored in an OWS Flight Dispatch Center database, and used to filter data displayed to the dispatcher and the crew.
- Creating events from daily North Atlantic Track (NAT) messages from the Gander Oceanic website (by converting them to AIXM first, serving them in a WFS and pushing them to the Event Service).
- Demonstrating the use of additional safety risk parameters (e.g. the probability of specific weather hazards), detailed in section 4.5.4.4.4.
- Testing some of the new weather concepts developed in the thread (such as support for on-demand CRS definition/conversion, access to >4D coverage information, etc).
- Demonstrating how application clients can use real-time weather information accessible via web services to enable an increased level of situational awareness for flights planners, pilots and operation centers in the following context:
    - The NASA's Airborne Science Program will be conducting an extended series of Science missions, flying the NASA Global Hawk UAS on equatorial flights, measuring atmospheric constituents. The flights will originate from the Navy Pacific Missile Range Facility, Kauai, Hawaii, Andersen Air Force Base, Guam,

and Darwin International Airport, Darwin, Australia. The flights will be of extended (30 hour) duration.

- Flight planners and pilots at the local operations centers, and the primary operation center at the NASA Dryden Flight Research Center, Edwards Air Force Base, Edwards California, will need accurate and up-to-date weather conditions in this extended area of operations.
- As part of OWS-8, such accurate and up-to-date weather conditions will be accessible via a WCS 2.0, that will be developed to 1) securely ingest weather radar data supplied by a major international carrier with routes over the pacific basin, and (2) convert the source data into WXXM 1.1. The weather WCS will endeavor to support the emerging Data Link concept as defined by the RTCA SC-206 wherever possible.

4.5.4.4.2 Authoritative Data Source

The Aviation Thread of OWS-8 will provide a proof-of concept on how the WFS-T (along with basic security and access control measures) can be used to update or insert new AIXM information back into the underlying database, while ensuring the integrity of the database as an Authoritative Data Source for AIXM (an official or recognized data source publishing reliable and accurate data for subsequent use by users).

The Authoritative Data Source scenario should cover:

- Update of AIXM features via WFS-T,
- Capturing of metadata for updated features using the draft AIXM Metadata profile. At a minimum, the metadata should include the timestamp of the transaction, and information about the originator of the new data, their role and their organization,
- Basic user authentication (based on user identity and role),
- Basic access control (based on matching user identity and role with AIXM features and attributes),
- Validation of data according to the AIXM 5.1 business rules, the rules defined in the Digital NOTAM Event Specification and other integrity rules (e.g. the new coordinates of an SUA are within the range of the SUA, etc)

Since the focus of OWS-8 is on demonstrating a proof-of-concept for supporting AIXM Authoritative Data Source, additional client development needed is minimal. Sample representative changes/updates will be drafted by FAA and the participants to cover the basic use cases, and will be provided as AIXM 5.1 messages.

4.5.4.4.3 Digital NOTAM Event Specification

The thread participants will refine realistic scenarios developed by FAA and EUROCONTROL based on the scenarios identified in Section 4 of the Digital NOTAM Event Specification. This involves implementing and testing scenarios including but not limited to the following types of events:

- Activation/deactivation of published ATS space
- Creation of ad-hoc SAA
- Creation of ad-hoc ATS airspace
- Route portion closure or opening

- Navaid unserviceable
- Aerodrome closure
- Runway closure
- Taxiway closure
- New obstacle
- Withdrawn obstacle
- Airport surface contamination

The testbed participants will have to create ad-hoc AIXM 5.1 data representing examples of digital NOTAMs as specified in the Digital NOTAM Event Specification, based on the baseline data provided by the sponsors.

4.5.4.4.4 Probabilistic Weather in Decision Making

The Aviation Thread of OWS-8 is an opportunity to demonstrate the potential of using probabilistic information in weather data in decision-support applications. The NOAA Meteorological Development Lab (MDL) will provide all the weather data (via WFS and WCS) as needed to support the scenarios described in this section. As with other scenarios, those will be discussed at the kickoff and refined during the course of the initiative.

Scenario I

Vacation, initial flight plan: Gulfstream JetProp Commander 980 @ 25kft from KLAX to KJAC, alternate KDIJ. Departure 9:30 LT. Flight time 3:30 h.

- Get TAFs for endpoints and alternate. Notes thunderstorms forecasted for KJAC and KDIJ in afternoon.
- Queries LAMP probabilities of thunderstorms & IFR conditions at arrival times (16Z-18Z) at both locations. Decides to proceed and file plan.

Scenario II

Business meeting, private plane, initial flight plan: Cessna 172S @ 10kft flying VFR from KBWI to KCRW, alternate K12V. Departure 0930Z. Flight time 1:20 h.

- Get TAFs for endpoints and alternate. Notes VFR at KBWI & MVFR conditions (5SM) at KCRW at K12V due to BR at 11Z (arrival time) with improving conditions thereafter.
- At 09Z, pilot queries LAMP probabilities of MVRF, IFR conditions at arrival time (10Z to 12Z) and decides the IFR probabilities are too high and delays departure.
- At 10Z and 11Z LAMP guidance continues to indicate high IFR probabilities for the next few hours. New 12Z TAF is issued and indicates that the 1 BR condition will dissipate by 14Z at KCRW. Pilot schedules departure at 13:30Z

Scenario III

Winter vacation, private plane, initial flight plan: Beechcraft KingAir B100 @ 24kft from KLVS to KSUN. Departure 1530Z. Flight time 3:45 h.

- Get TAFs for endpoints. Pilot notes IFR conditions at KSUN due to ceilings around Queries LAMP probabilities for LIFR at KSUN for which aircraft is not equipped. LIFR probabilities are low, also notes that LAMP is forecasting 23 knot gusts in the afternoon much of it direct crosswind which are not in the TAF. Pilot decides to depart for KSUN.

- While enroute, pilot subscribes for observations and updates to TAF and LAMP guidance for KSUN. At each hour, LAMP guidance increases the probability of LIFR conditions and wind speeds and gusts expected at KSUN around arrival time.
- 1h 15 minutes prior to arrival, light snow begins to fall at KSUN with 33kt gusts. Pilot files updated flight plan indicating KPIH as an alternate. 35 minutes before arrival, KSUN TAF is updated indicating IFR conditions both in ceiling and visibility and strong winds, occasional LIFR condition due to snow reducing visibility and ceilings. Pilot decides to fly to alternate destination, KPIH which remains MVFR.

Scenario IV

A parcel shipping company uses a fleet of Boeing 727-200 aircraft daily to deliver its packages. Using a 'hub-and-spoke' sort and distribution system, meteorologists must forecast weather conditions at several airport hubs at critical early morning hours, 14 to 16 hours in advance. Cost/Loss analysis indicates that it is better for the company to increase staffing and send flights to alternate hubs when the risk of LIFR condition at the primary hub is 40% or greater.

Mid-February, at the primary hub airport, a stationary front lies just to the south. MVFR and occasional IFR conditions at the airport are expected to persist for 24 to 36 hours. Precipitation is expected within the next 12 to 18 hours. Current TAF for the primary hub airport has a PROB group of IFR ceilings and rain/snow during the overnight hours. LAMP guidance for the same time period indicates high probability of IFR conditions and snow with possibility of freezing precipitation as well. As each hour passes with each LAMP guidance update, and as the critical decision period approaches, LIFR and freezing precipitation probabilities at the hub airport steadily increases for the nighttime period. At decision time, probability of LIFR condition at the hub airport reaches 37% with 44% chance of freezing rain and/or sleet. The meteorologist, examining the current LAMP probability trends, decides to send more than half its planes to alternate hubs.

4.5.5 Aviation Thread 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 in the following areas

- Aeronautical and Weather models and encodings (AIXM, Digital NOTAM Event Schema, WXXM, GML and draft GML profile, EXI, Binary XML, Sun Fast Infoset, ISO 19139 Metadata XML and draft AIXM metadata profile).
- Information filtering, integration, styling and sharing (Filter Encoding, SLD, GeoRSS).
- Authentication and authorization encodings (SAML, GeoXACML/XACML).

4.5.5.1 AIXM

***Relevant Specification and Documents**:*

- *AIXM 5.1* http://www.aixm.aero
- *OWS-7 AIXM Assessment Report OGC 10-131* http://portal.opengeospatial.org/files/?artifact_id=40502

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 4-30), 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.

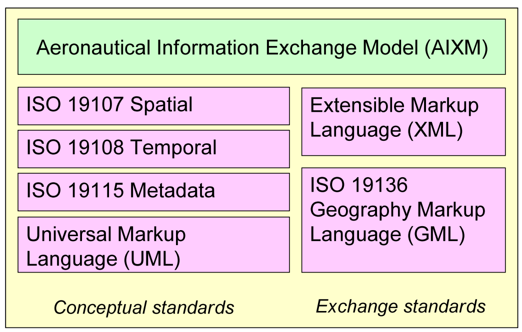


Figure 4-30. AIXM Based on International Standards

4.5.5.2 Digital NOTAM Event Specification

***Relevant Specification and Documents**:*

- *Digital NOTAM Event Specification v 0.3* (requires AIXM forum username and password) https://www.eurocontrol.int/saforum//downloadAttachment.do?attachementId=6118&timeout=0
- *Digital NOTAM XML schema and encoding examples* (requires AIXM forum username and passoword) https://www.eurocontrol.int/saforum//downloadAttachment.do?attachementId=6119&timeout=0

The Digital NOTAM Event Specification is being developed by a small focus group composed of operational and technical experts from EUROCONTROL, FAA, ANSP, airlines and industry. It defines the rules for harmonized encoding (in AIXM 5.1) 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.

The Aviation Thread of OWS-8 will focus on validating the Digital NOTAM Event Specification and use, test and advance the associated AIXM Event Schema. The schema is provided as an

extension the core AIXM 5.1 and is designed as a container for Digital NOTAM. It enables in particular to associate digital AIXM encodings of the events with the classical text NOTAM, and enables the storage and unique identification of the events.
Note that the thread participants will have to create ad-hoc AIXM 5.1 data representing examples of digital NOTAMs as specified in the Digital NOTAM Event Specification, based on the baseline data provided by the sponsors.

4.5.5.3 WXXM

Relevant Specifications:

- *Weather Exchange Information Model WXXM*
http://www.eurocontrol.int/aim/public/standard_page/met_wie.html

The WXXM is part of a family of platform (technology) independent, harmonized and interoperable information exchange models designed to cover the information needs of ATM. The first public release of WXXM occurred in May 2007. WXXM 1.1 became available in March 2009 and incorporates modifications to earlier versions based on stakeholder input and intensified FAA-EUROCONTROL cooperation on a harmonized pan-Atlantic approach towards Weather Information Modeling.

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/om).

4.5.5.4 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
- *AIXM 5.1 Draft GML Profile – OGC Aviation Domain Working Group (DWG) public wiki page* http://external.opengeospatial.org/twiki_public/bin/view/AviationDWG/WebHome

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. Resources used to create the current draft profile include the simple feature profile by OGC, EAD document for current static data (Europe), AMDB requirements and Airport GIS database requirements (FAA). The document also provides guidelines for the use of GML constructs in AIXM data sets.

4.5.5.5 EXI

Relevant Specifications:

- *Efficient XML Interchange (EXI)* http://www.w3.org/TR/2008/WD-exi-20080919/

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.

4.5.5.6 Binary XML

Relevant Documents:

- *Binary Extensible Markup Language (BXML (Encoding Specification) OGC Discussion Paper 03-002r9* http://portal.opengeospatial.org/files/?artifact_id=13636

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 n-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.

Within aviation, the OGC B-XML specification is the technical foundation of the ARINC816 specification defining an "Embedded Interchange Format For Airport Mapping Database", and is already used operationally on-board aircraft by Airport Navigation Systems. The use of OGC B-XML specification is also considered for the future open embedded format for on-board navigation databases (formerly named NDBX), whose development is underway within the ARINC424A committee. A description of draft indexed B-XML format for navigation database is available at the ARINC424A web site. http://www.aviation-ia.com/aeec/projects/ndbx/ndbx_icd_ir01_signe.pdf.

4.5.5.7 Sun Fast Infoset

Relevant Specification and Documents:

- *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/

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.

4.5.5.8 ISO 19139 Metadata XML Schema Implementation and AIXM Draft Metadata Profile

Relevant Specification and Documents*:*

- *ISO/TS 19139:2007 – Geographic Information – Metadata – XML Schema Implementation*
- *Requirements for Aviation Metadata and Guidance on the Aviation Metadata Profile – OGC Aviation Domain Working Group (DWG) public wiki page* http://external.opengeospatial.org/twiki_public/bin/view/AviationDWG/WebHome

ISO/TS 19139:2007 defines 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 Aviation DWG within OGC is currently wrking on two discussions papers, "Requirements for Aviation Metadata" and "Guidance on the Aviation Metadata Profile", that 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. Eventually, the objective of the Aviation DWG is to release the two papers as OGC Best Practice documents.

4.5.5.9 Filter Encoding

Relevant Specifications:

- *OGC Filter Encoding Implementation Specification 2.0; ISO 19143 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 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.

The FE 2.0 has recently been jointly approved by ISO and OGC and will soon become available on the public OGC website.

FE 2.0 will be used in the Aviation Thread to support AIXM and WXXM queries and 4-D trajectory information filtering.

4.5.5.10 SLD

Relevant Specification and Documents:

- *ISO 19117:2005 – Geographic Information- Portrayal*
- *OGC 10-127r1 – OWS-7 Aviation Portrayal Engineering Report* http://portal.opengeospatial.org/files/?artifact_id=40134
- *OGC 05-078r4 and 08-064 – SLD Profile of Web Map Service (WMS*) http://portal.opengeospatial.org/files/?artifact_id=22364 with CR http://portal.opengeospatial.org/files/?artifact_id=28921&version=1
- *OGC 05-077r4 – Symbol Encoding (SE)* 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 Aviation Thread of OWS-8 will build on the portrayal work of the OWS-7 Aviation work (in coordination with the FDF thread) 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.

Note again that the portrayal recommendations for Aviation should be coordinated with the Cross-Community Interoperability (CCI) Thread portrayal requirement (section 4.4.2.2).

4.5.5.11 GeoRSS

Relevant Documents:

- *Geographically Encoded Objects for RSS Feeds GeoRSS* Webpage http://georss.org

GeoRSS describes a number of ways to encode location in RSS feeds. GeoRSS-Simple supports basic geometries (point, line, box, polygon) and covers the typical use cases when encoding locations. GeoRSS-GML is a formal GML Application Profile and supports a greater range of features, notably coordinate reference systems other than WGS-84. Both formats are designed for use with Atom 1.0, RSS 2.0 and RSS 1.0.

The Event Notification Architecture may leverage GeoRSS as one of the mechanisms for communicating information about aeronautical and weather data changes or availability to the users.

4.5.5.12 Security Access Markup Language (SAML)

Relevant Specifications:

- *Security Assertion Markup Language (1.1 and 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, attributes, and entitlements of a subject (an entity that is often a human user) to other entities, such as a partner company or another enterprise application.

4.5.5.13 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 context schema that includes a specification of the generic data level interface to the XACML processor/Policy Decision Point (PDP). Since GeoXACML only defines extensions to the policy-encoding schema, it doesn't affect the XACML 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) also referred to as an Authentication Service, 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 (section 4.5.6.9).

4.5.6 Aviation Thread 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-8, those services are

- Web Feature Service (WFS) for access to aeronautical and weather information.
- Web Coverage Service (WCS) for access to weather information.
- Feature Portrayal Service (FPS) for portraying AIXM and WXXM feature data by applying SLD feature style descriptions.
- Event Service, Notification Services (OASIS Web Services Notification), OGC Web Notification Service (WNS), WS-Eventing and other services as needed to support the Event Notification Architecture.
- Catalog Service for the Web (CSW) ebRIM for managing publication, discovery and access to symbols, styles, UoMs and code lists for AIXM and WXXM.
- Authentication and authorization services.
- Aviation Clients.

4.5.6.1 Web Feature Service

Relevant Specifications:

- *ISO/IEC FDIS 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, 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 primarily serve and query AIXM 5.1 aeronautical features including airports, airspace, navigational aids and fixes, obstacles, and/or procedures (approaches). The WFS shall support 4-D trajectory information filtering (temporal queries) and transactions (for posting events and updating features accordingly). WFS 2.0 will also be used to serve and query WXXM 1.1 data.

4.5.6.2 Web Coverage Service

Relevant Specifications:

- *OGC Web Coverage Service specification v 2.0* http://www.opengeospatial.org/standards/wcs

The Web Coverage Service (WCS) supports the networked interchange of geospatial data as "coverages" containing values or properties of geographic locations. Unlike the Web Map Service, which filters and portrays spatial data to return static maps (i.e., server-rendered pictures), the Web Coverage Service provides access to raw (unrendered) geospatial information and multi-valued coverages (such as multi-spectral images and terrain models), typically for input into scientific models and other client applications including simple viewers.

WCS 2.0 will be used in the Aviation thread to serve and query WXXM 1.1 and possibly other weather data.

4.5.6.3 Feature Portrayal Service

Relevant Specifications & Documents:

- *OGC 10-127r1 – OWS-7 Aviation Portrayal Engineering Report*
  http://portal.opengeospatial.org/files/?artifact_id=40134
- *OGC 05-078r4 and 08-064 – SLD Profile of Web Map Service (WMS)*
  http://portal.opengeospatial.org/files/?artifact_id=22364
- *OGC 05-012r1 – Symbology Management*
  http://portal.opengeospatial.org/files/?artifact_id=13285
- *Feature Portrayal Service and Styled Layer Descriptor*
  http://www.opengeospatial.org/standards/sld

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 4-31.

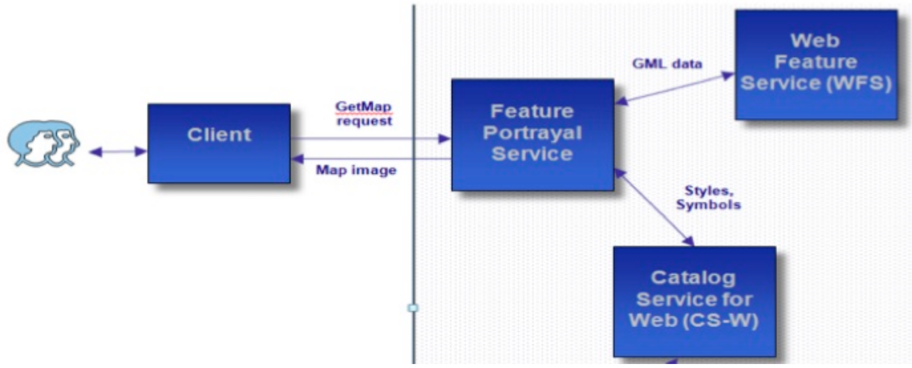


Figure 4-31. Feature Portrayal Service

The Aviation Thread of OWS-8 will continue the work started in OWS-7 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.

4.5.6.4 Event Service

Relevant Specification and Documents:

- *OGC 10-079r3 OWS-7 Aviation Architecture Engineering Report*
  http://portal.opengeospatial.org/files/?artifact_id=40133
- *OGC 10-060r1 OWS-7 Event Architecture Engineering Report -*
  http://portal.opengeospatial.org/files/?artifact_id=39509
- *OWS-6 AIM Event Service*
  http://portal.opengeospatial.org/files/?artifact_id=33208&version=1
- *Web Notification Service Best Practices Paper 0.0.9*
  http://portal.opengeospatial.org/files/?artifact_id=18776

The Aviation Thread of OWS-8 will build on the Event Notification Architecture developed in OWS-6 and OWS-7 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 4-32). The OWS-6 and OWS-7 Event Architecture was implemented using the WS-* standards from OASIS and W3C (including WSDL, SOAP and WS-Resource).

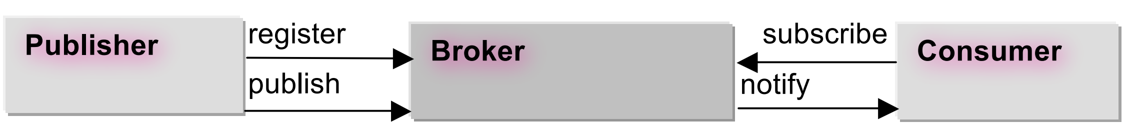


Figure 4-32. Event Notification System Overview

4.5.6.5 OASIS Web Services Notification

Relevant Specifications:

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

4.5.6.6 Web Notification Service

Relevant Documents:

- *Web Notification Service Best Practices Paper 0.0.9* 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 protocols, 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.

4.5.6.7 WS-Eventing

Relevant Specifications:

- *W3C WS-Eventing* http://www.w3.org/Submission/WS-Eventing

This specification defines a protocol for one Web service (called a "subscriber") to register interest (called a "subscription") with another Web service (called an "event source") in receiving messages about events (called "notifications" or "event messages"). The subscriber may manage the subscription by interacting with a Web service (called the "subscription manager") designated by the event source.

To improve robustness, a subscription may be leased by an event source to a subscriber, and the subscription expires over time. The subscription manager provides the ability for the subscriber to renew or cancel the subscription before it expires.

There are many mechanisms by which event sources may deliver events to event sinks. This specification provides an extensible way for subscribers to identify the delivery mechanism they prefer. While asynchronous, pushed delivery is defined here, the intent is that there should be no limitation or restriction on the delivery mechanisms capable of being supported by this specification.

4.5.6.8 CSW ebRIM

Relevant Specifications and Documents:

- *OGC 07-006r1 OGC Catalog Service Implementation Specification 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

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.

The Aviation Thread of OWS-8 will build on the results of the OWS-7 Aviation Portrayal effort (see reference above for the OWS-7 Aviation Portrayal Engineering Report). The OWS-7 Portrayal effort successfully demonstrated integration of data services (both vector and gridded), portrayal services, Symbol/Style Registries and Clients to meet Aviation portrayal requirements. The OWS-7 effort involved the design of a portrayal registry model, that was implemented as a set of ebRIM Classes, Associations and Classifications (within the 'Type' Classification Scheme) which where then loaded into a CSW-ebRIM registry.

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

4.5.6.9 Authentication and Authorization Services

Relevant Specifications and Documents:

- *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
- *OGC 10-192 Authentication Interoperability Experiment (IE) Engineering Report*

The Aviation Thread of OWS-8 will setup the following services as needed to support the AIXM Authoritative Data Source requirement (section 4.5.2.2.3):

- Authentication services (who is accessing the resources?): to determine the identity or role of a party attempting to perform some action such as accessing a resource or participating in a transaction.
- Authorization services (what can they do?): to determine whether some party is allowed to perform a requested action or access particular resources and to grant them permissions based upon access right policies. The XACML Information Flow Model, below, defines the architecture of a modular and distributed access control system. In addition, it defines the exchange of messages between the components and the structure of the messages.

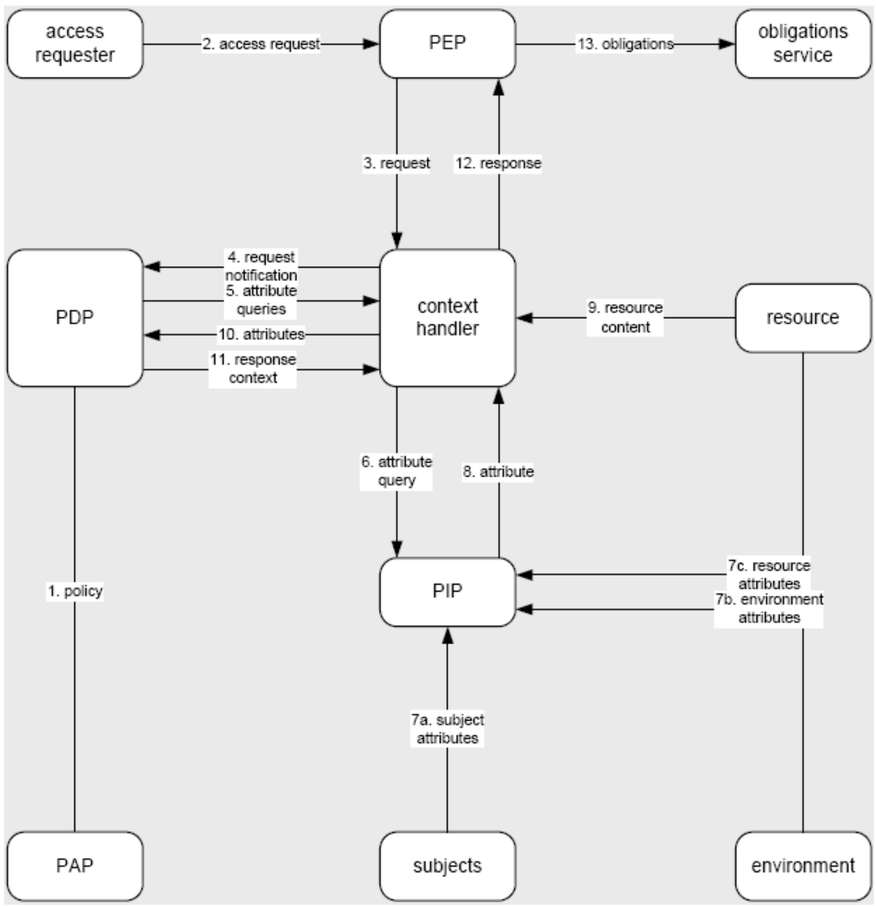


Figure 4-33. XACML Information Flow Model

Note that the emphasis in the Aviation Thread is not on the development or advancement of the security architecture but rather on the direct (and simple) application of the established authentication/authorization components in support of the Authoritative Data Source requirement.

4.5.6.10 OWS-8 Aviation Client requirements

The Aviation Clients in the Aviation Thread of OWS-8 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. The Aviation Clients can be developed as either thin or thick clients, and can act as proxies for EFB/handheld applications, flight dispatch/airline operations applications, avionic system applications, or any other applications that can benefit from the combination of functionality developed during the thread in support of the Enterprise Viewpoint scenarios.

The Aviation Client(s) in this thread shall support the requirements listed in 4.5.2, more specifically:

- AIXM 5.1 (including metadata profile) WFS-T 2.0 (including compression) and FE. 2.0,
- WXXM 1.1 WFS/WCS (including on-demand CRS definition/transformation and >4D coverages),
- The Event Architecture to-be-agreed-on in the thread including subscription/unsubscription to events and receipt/display/interpretation of events (using the Digital NOTAM Event Specification Event Schema),
- The Security Architecture to-be-agreed-on in support the authoritative data source requirement,
- The Portrayal architecture to-be-agreed-on in the thread (including FPS and SLD),
- One or more scenarios, as defined in section 4.5.4.4.

4.5.7 Aviation Thread 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 4-34 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 read/write access to 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.

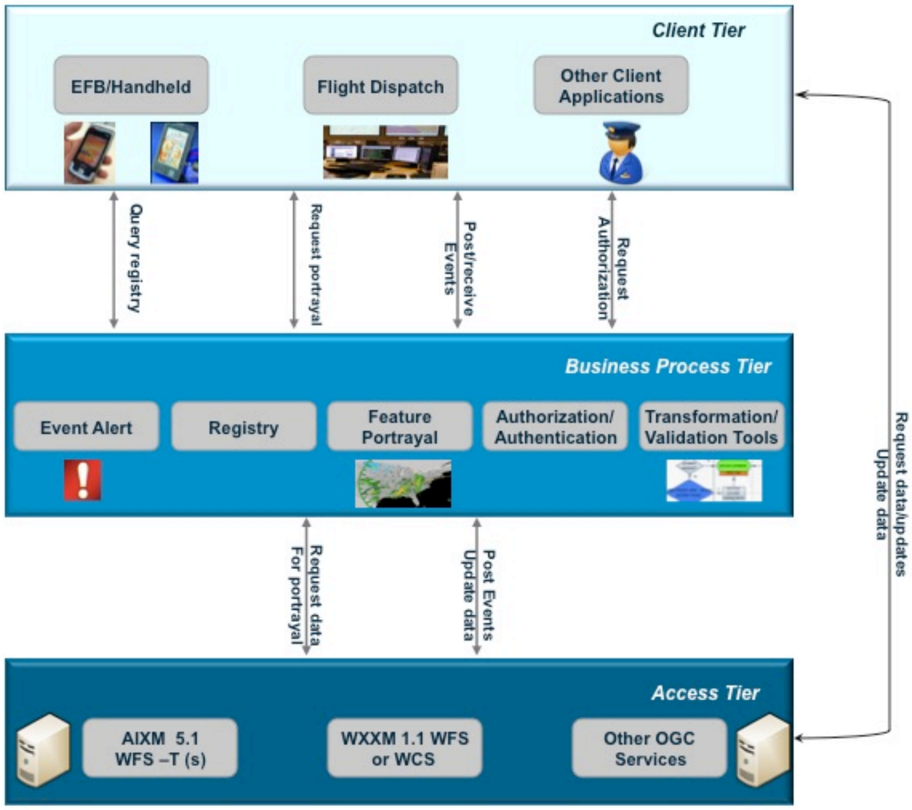


Figure 4-34. Aviation Thread Engineering Viewpoint