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Request for Quotation (RFQ)
And
Call for Participation (CFP)
OGC Web Services Initiative - Phase 7 (OWS-7)

Annex B
OWS-7 Architecture

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1 OWS-7 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 7 (OWS-7) 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-7 development, which involves multiple interdependent activity threads. The requirements and architectures presented here are based upon a collaborative effort between OWS-7 Sponsors and OGC's IP program and project management staff, called the IP Team. The OWS-7 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-7 development threads.

Section 3 discusses the architectural approach and technical baseline for OWS-7.

Section 4 discusses the architectural approaches and issues for each of the OWS-7 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-7 Initiative Threads

In June of 2009, the OGC issued a call for sponsors for the OWS-7 interoperability initiative to advance OGC's open framework for interoperability in the geospatial industry. Three meetings were conducted with potential OWS-7 sponsors to review the OGC technical baseline, discuss OWS-6 results, and identify OWS-7 requirements. During the OWS-7 Concept Development phase, a Fusion Standards Study was also conducted, to better inform the requirements for OWS-7 development.

2.1 Fusion Standards in OWS-7

Reference: Fusion Standards Study Engineering Report, OGC Document 09-138, draft 02 October 2009. 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 an OGC Engineering Report (ER). 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.

- State A (As-Is): Lack of identified and adopted standards results in multiple islands of data and stovepipe applications and services that are difficult to automate and scale for large data volumes and challenging analytical problems.
- State B (Target): Standards-based data, applications and services enable an automated and interoperable fusion environment supporting secure sharing of data and transparent reuse of pluggable services for handling large data volumes and unanticipated analytical challenges.

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.

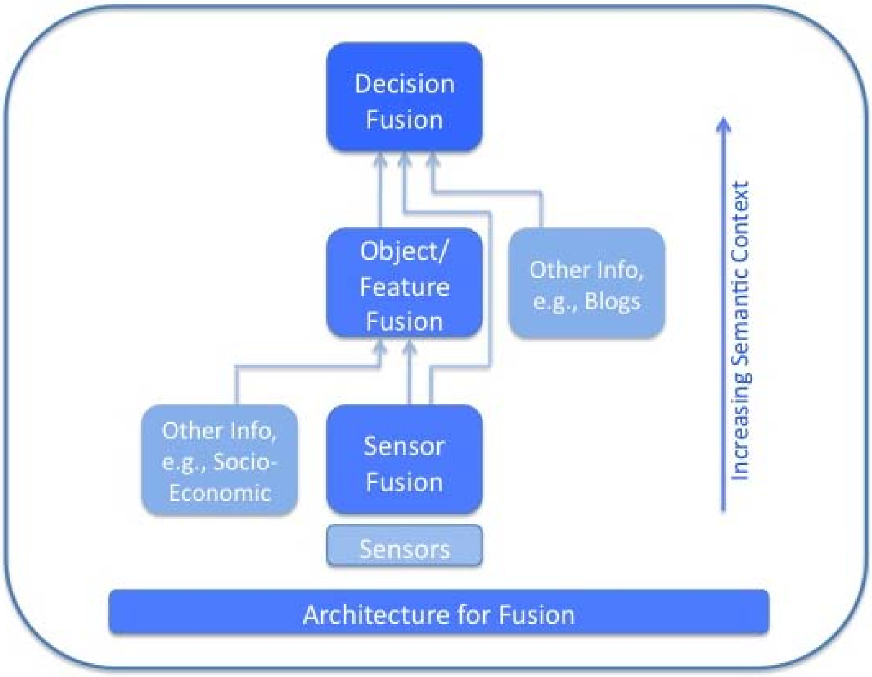

Figure 2-1. Categories of Fusion

The sponsors have selected elements of the Fusion Study results to include in OWS-7, as shown in Figure 2-2. Sensor Fusion is addressed in the Sensor Fusion Enablement (SFE) thread. Object/Feature Fusion and Decision Fusion are addressed in the Feature and Decision Fusion (FDF) thread.

The SFE and FDF threads of OWS-7 build upon the threads of previous OWS test beds. SFE builds on the Sensor Web Enablement (SWE) and Geospatial Processing Workflow (GPW) thread by including Sensor Fusion topics and applying workflow to sensor fusion. FDF also builds on the previous Geospatial Processing Workflow (GPW) thread, as well as Decision Support Services (DSS) thread, by including feature definition and workflow of GPW along with decision support topics. In this way, processing workflow is more explicitly a cross-thread topic.

The third activity thread in OWS-7 is the Aviation Thread. This began as Aeronautical Information Management (AIM) Thread in OWS-6, addressing the use of web services, event notifications, and AIXM 5.0 for Electronic Flight Bag (EFB) applications in the aviation industry. The Aviation Thread in OWS-7 represents an expansion of scope, to include flight planning and aviation operations more broadly.

An introduction to each of these threads is given below, followed by a detailed discussion of the architectural implications of the initiative threads. Cross-thread topics include events and notifications, cataloguing, Web Processing Service (WPS), and the Integrated Client.

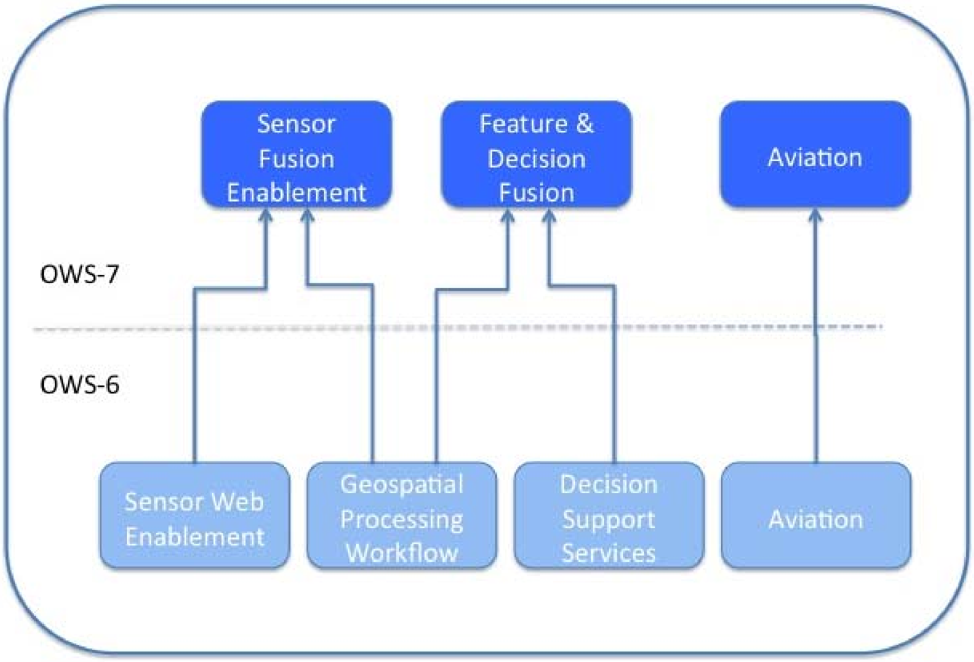

Figure 2-2. Evolution of OWS Testbed Threads

2.2 Sensor Fusion Enablement (SFE)

The SFE Thread builds on the OGC Sensor Web Enablement (SWE) framework of standards that has achieved a degree of maturity through previous OWS interoperability initiatives and deployments worldwide. OWS-7 will focus on integrating the SWE interfaces and encodings with workflow and web processing services to perform sensor fusion. SFE will continue the development of Secure SWE architecture, as well as the interoperability of SWE and CCSI.

Emphasis for SFE during this phase of the OWS testbed will be the following:

- Motion Video Fusion. Geo-location of motion video for display and processing. Change detection of motion video using Web Processing Service with rules.
- Dynamic Sensor Tracking and Notification. Track sensors and notify users based on a geographic Area of Interest (AOI). The sensor and the user may be moving in space and time.
- Trusted SWE in an untrusted environment. Build on OWS-6 Secure Sensor Web development, to investigate secure SOS, SPS in more depth.
- CCSI-SWE Best Practice. Building on OWS-6, develop an ER to be considered by the OGC Technical Committee as a Best Practice.

For detailed SFE requirements and deliverables, see Section 4.2.

2.3 Feature / Decision Fusion (FDF)

The FDF Thread builds on OWS-6 GPW and DSS work, in particular to advance the state of information cataloguing, Web Processing Services (WPS) profiles, and the Integrated Client. The following task areas have been identified for Feature and Decision Fusion:

- Schema Automation. Transformation from UML to profiles of GML and KML, including generation of constraints.
- Data Discovery and Organization. Use of thematic categories in multi-source data discovery, including augmented metadata for quality of source, fitness for use, and uncertainty of the data values, propagated through usage and workflow.
- Feature and Statistical Analysis (FSA). WPS profiles for feature fusion, including statistical analysis, vector and topological processing. WFS, WMS and WMTS will be used to support statistical mapping.
- Geosynchronization. Web services and client components to support synchronization of geospatial data and updates across a hierarchical Spatial Data Infrastructure (SDI).
- Data and Analysis Sharing. The use of OWS Context for collecting links to web services and analysis results.
- Alerting. OASIS Common Alerting Protocol (CAP) 2.0 with GML application schema.
- Integrated Client. A field-ready client application to support and display sensor information, cataloguing metadata, notification alerts, statistical and FSA, and OWS Context. This client will include an embedded lightweight WFS server for geosynchronization support.

For detailed FDF requirements and deliverables, see Section 4.3.

2.4 Aviation

The Aviation Thread of OWS-7 builds on the AIM thread of OWS-6 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 uses 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. FAA and EUROCONTROL are using AIXM as an integral part of their efforts to modernize their aeronautical information procedures and to transition 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. Indeed, it is expected that the results of the Aviation Thread of OWS-7 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.

WXXM is also jointly developed by FAA and EUROCONTROL, as a proposed standard for the exchange of aeronautical weather information in the context of a net-centric and global interoperable Air Transport System (ATS). 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.

In OWS-7, the goal of the Aviation Thread will be on investigating and demonstrating the applicability of AIXM and WXXM along with relevant OGC specifications and web services to applications and tools that support Airline Operations Centers and Flight Dispatch applications. Such applications provide information for representing a Common Operating Picture; supporting flight planning (including General Aviation) and preparation (MET and AIM); calculating weight and balance; estimating fuel requirements; in-flight emergency response; etc. The primary focus in OWS-7 is on ground usage of the information, although provision of information packages to the crew, on the ground and in the air, is also of interest.

To support the above goal, the OWS-7 Aviation Thread will cover the following tasks:

- Evaluation and advancement of AIXM, in the areas of using and testing new AIXM 5.1 features, developing components/tools for generating, validating, converting, and parsing AIXM, addressing feature metadata requirements and performance constraints, and supporting the portrayal of AIXM information.
- Evaluation and advancement of WXXM, focusing on the incorporation and demonstration new weather concepts such as the 4-D Weather Data Cube, including the impact of such concepts on the Event Notification Architecture, the support for probabilistic events, and the definition and usage of the time model in WXXM.
- Advancement of the Event Notification Architecture developed and exercised in OWS-6 to support multiple sources of events and multiple types of events and data changes (AIXM, WXXM), and to investigate different delivery protocols (push/pull), registration and subscription lifecycle management approaches, and domain/schema-specific matching between events and subscriptions.
- Integration of AIXM/WXXM in the FAA SWIM environment, focusing on investigating approaches for leveraging SWIM Interface Management, Messaging and Security capabilities, as well as enabling Aviation clients to access SWIM services in addition to OGC services.

For detailed Aviation requirements and deliverables, see Section 4.4.

3 OWS-7 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-7 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-7.

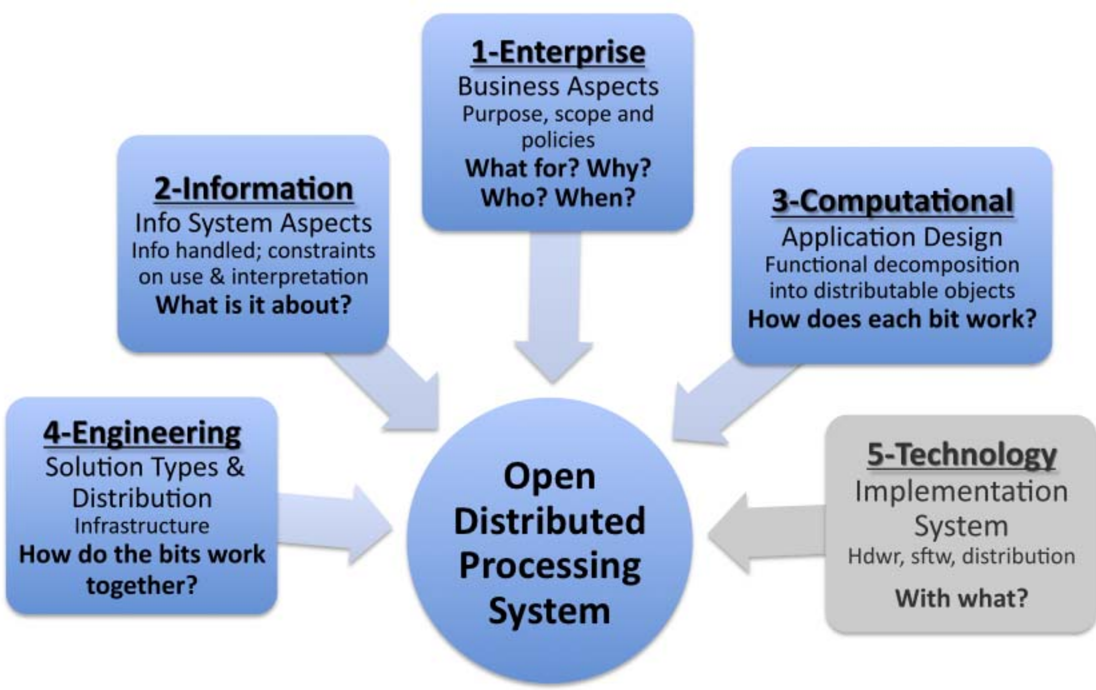

Figure 3-1. RM-ODP Viewpoints used in OGC Reference Model

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

Threads in OWS-7 will use GML version 3.2.1, which is available as OGC Document 07-036, subject to corrections and revisions, documented in OGC 07-061. This version of GML is also adopted as ISO 19136:2007. Many, if not most, specifications that depend on GML are now based on GML 3.1.1. We shall allow a migration path here.

Several documents were approved for public release at the recent OGC TC/PC meeting in September 2009 and are being processed for public release. These documents will become available over the next few weeks. If a proposer needs a specific document that has not yet been published to the public link above, please contact the OGC Technology Desk (techdesk@opengeospatial.org).

What follows are several lists of reference material, largely generated through the activities of OGC and other standards development organizations (SDO). The first table lists the approved OGC Standards that are relevant to various parts of OWS-7. However, in some cases an OWS-7 thread may call for a version which is different from the approved specifications in this table.

Table 3-1. Approved OGC Standards Related to OWS-7

Title	Version	Document #	Date
Catalog Service for the Web (CSW)	2.0.2	07-006r1, 07-010, 07-110r2, 07-144r2, 07-045	2007-02-23
Web Coverage Service (WCS)	1.1.2	07-067r5, 07-066r5	2008-03-19
Web Feature Service (WFS)	1.1	04-094	2005-05-03
Web Map Service (WMS)	1.3.0	06-042	2006-03-15
Web Map Context (WMC) and Corrigendum	1.1	05-005, 08-050	2005-01-19, 2008-03-14
Web Processing Service (WPS) and Corrigendum	1.0	05-007r7, 08-091r6	2007-06-08
Web Service Common	1.1	06-121r3	2007-02-09
Geography Markup Language (GML)	3.2.1	07-036, 07-061	2007-08-27
Styled Layer Descriptor (SLD)	1.1	05-078r4	2007-06-29
Symbology Encoding (SE)	1.1	05-077r4	2007-1-18
Filter Encoding (FE)	1.1	04-095	2005-05-03
Geospatial eXtensible Access Control Markup Language (GeoXACML)	1.0	07-026r2, 07-098r1, 07-099r1	2008-02-20
KML	2.2	07-147r2	2008-04-14
Open Location Services (OpenLS)	1.1	05-016	2005-05-02
Observations and Measurements - Part 1: Observation schema	1.0	07-022r1, 08-022r1	2007-12-08, 2008-02-25

Title	Version	Document #	Date
Observations and Measurements - Part 2: Sampling Features	1.0	07-022r3	2007-12-08
SensorML with corrigendum	1.0.1	07-000, 07-122r2	2007-07-17, 2007-10-25
Sensor Observation Service (SOS)	1.0	06-009r6	2007-10-26
Sensor Planning Service (SPS)	1.0	07-014r3	2007-08-02
The Specification Model — A Standard for Modular specifications	1.0	08-131r3	200907-06

3.3 GML Profiles

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. Presumably these may need only minor changes to become compliant with GML 3.2.1, and in some cases such as GML Simple Features Profile, an OGC Revision Working Group is already working on a draft Change Request to bring this Profile into compliance with GML 3.2.1. The following profiles should be used wherever appropriate, and any changes required for compliance with GML 3.2.1 should be documented as a Change Request to the appropriate OGC Working Group.

Table 3-2. GML 3.1.1 Profiles which may be of use in OWS-7

Title	Version	Document #	Date
GML 3.1.1 Common CRSs profile	1.0.0	05-095r1	2006-07-18
GML 3.1.1 Common CRSs profile Corrigendum	1.0.1	06-113	2006-07-19
GML 3.1.1 Grid CRSs profile	1.0.0	05-096r1	2006-07-18
GML 3.1.1 Grid CRSs Profile Corrigendum	1.0.1	06-111	2006-07-19
GML 3.1.1 CRS support profile	1.0.0	05-094r1	2006-07-18
GML 3.1.1 Simple dictionary profile	1.0.0	05-099r2	2006-07-18
GML 3.1.1 Simple features profile	1.0.0	06-049r1	2006-05-08

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

Table 3-3. Approved OGC Best Practice Documents Related to OWS-7

Title	Version	Document #	Date
A URN namespace for OGC	0.4	07-107r3	2008-05-02
Binary Extensible Markup Language (BXML) Encoding Specification	-	03-002r9	2006-01-18
Definition identifier URNs in OGC namespace	1.1.2	07-092r1	2007-11-14
DGIWG WMS 1.3 Profile and systems requirements for interoperability for use within a military environment	0.9.0	09-102	2009-09-02

Title	Version	Document #	Date
EO Products Extension Package for ebRIM (ISO/TS 15000-3) Profile of CSW 2.0	0.1.9	06-131r4	2008-07-08
FGDC CSDGM Application Profile for CSW 2.0	-	06-129r1	2006-12-26
Gazetteer Service - Application Profile of the Web Feature Service Implementation Specification	0.9.3	05-035r2	2006-07-27
GML Application Schema for EO Products	0.9.0	06-080r2	2007-08-16
GML Encoding of Discrete Coverages (interleaved pattern)	0.2.0	06-188r1	2007-05-17
GML PIDF-LO Geometry Shape Application Schema for use in the IETF	0.1.0	06-142r1	2007-05-17
OpenGIS Sensor Planning Service Application Profile for EO Sensors	0.9.5	07-018r2	2008-01-21
OpenGIS Web services architecture description	0.1.0	05-042r2	2005-11-21
Ordering Services for Earth Observation Products	0.9.0	06-141r2	2007-08-15
Reference Model for the ORCHESTRA Architecture	2.1.0	07-097	2007-10-05
Sensor Alert Service	0.9.0	06-028r5	2007-05-16
Sensor Web Enablement Architecture	0.4.0	06-021r4	2008-08-20
Specification best practices	1.0.0	06-135r1	2007-01-29
Units of Measure Recommendation	1.0.0	02-007r4	2002-08-19
Web Coverage Processing Service (WCPS)	-	06-035r1	2006-07-26
Web Map Services - Application Profile for EO Products	0.2.0	07-063	2007-08-15
Web Notification Service	-	06-095	2007-01-25

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

These specific reports resulted from OWS-6, and are the most recent foundational material for OWS-7. These are not all required or normative. Schemas for some of these documents can be found at the Discussion Paper Schema Repository.

Table 3-4. OWS-6 Public Engineering Reports related to OWS-7

Title	Version	Document #	Date
OWS-6 AIM Engineering Report	0.3.0	09-050r1	2009-07-27
OWS-6 3D Flythrough (W3DS) ER	0.3.0	09-075r1	2009-08-05
OWS-6 Common CBRN Sensor Interface (CCSI)-Sensor Web Enablement (SWE) ER	0.3.0	09-007	2009-10-09
OWS-6 DSS ER – SOAP/XML and REST in WMTS	0.3.0	09-006	2009-08-05

Title	Version	Document #	Date
OWS-6 Geoprocessing Workflow Architecture ER	0.3.0	09-053r5	2009-10-09
OWS-6 GeoProcessing Workflow Thread Summary ER	0.3.0	09-063	2009-09-11
OWS-6 Georeferenceable Imagery ER	0.3.0	09-034	2009-07-29
OWS-6 GeoXACML ER	0.3.0	09-036r2	2009-07-24
OWS-6 GML Profile Validation Tool ER	0.3.0	09-038r1	2009-08-14
OWS-6 Outdoor and Indoor 3D Routing Services ER	0.3.0	09-067r2	2009-09-11
OWS-6 Secure Sensor Web ER	0.3.0	08-176r1	2009-07-29
OWS-6 Security ER	0.3.0	09-035	2009-10-09
OWS-6 SensorML Profile for Discovery ER	0.3.0	09-033	2009-07-29
OWS-6 Sensor Web Enablement (SWE) ER	0.3.0	09-064r2	2009-09-11
OWS-6 Styled Layer Descriptor (SLD) Changes ER	0.3.0	09-015	2009-09-11
OWS-6 SWE Event Architecture ER	0.3.0	09-032	2009-07-29
OWS-6 SWE Information Model ER	0.3.0	09-031r1	2009-07-16
OWS-6 SWE PulseNet ER	0.3.0	09-073	2009-08-05
OWS-6 Symbology Encoding Harmonization ER	0.3.0	09-012	2009-08-17
OWS-6 Symbology Encoding (SE) Changes ER	0.3.0	09-016	2009-09-11
OWS-6 UTDS-CityGML Implementation Profile	0.3.0	09-037r1	2009-07-20
OWS-6 WPS Grid Processing Profile ER	0.3.0	09-041r3	2009-07-24

The next list of Engineering Reports, Discussion Papers, and Interoperability Program Reports are largely the result of test beds prior to OWS-6. These discussion papers 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.

Table 3-5. Pre-OWS-6 Discussion Papers Related to OWS-7

Title	Version	Document #	Date
3D-Symbology Encoding Discussion Draft	0.0.1	09-042	2009-10-13
Access Control & Terms of Use (ToU) "Click-through" IPR Management "	1.0.0	05-111r2	2006-05-09
Catalog 2.0 Accessibility for OWS3	-	05-084	2006-05-09
Cataloguing of ISO Metadata (CIM) using the ebRIM profile of CS-W	0.1.7	07-038	2007-06-06
CF-netCDF Encoding Specification	0.1.0	09-122	2009-10-13
Discussions, findings, and use of WPS in OWS-4	0.9.1	06-182r1	2007-06-06
EO Application Profile for CSW 2.0	1.4.0	06-079r1	2006-06-06
Event Pattern Markup Language (EML)	0.3.0	08-132	2008-11-05
Feature Portrayal Service	0.0.30	05-110	2006-04-19
Feature Styling IPR	0.4.1	06-140	2007-06-08
Feature Type Catalogue Extension Package for ebRIM Profile of CSW 2.0	0.1	07-172r1	2008-05-13
Frame image geopositioning metadata GML 3.2 application schema	-	07-032	2007-06-06

Title	Version	Document #	Date
GeoDSS Mass Market	0.0.1	07-004	2007-05-07
GeoDRM Engineering Viewpoint and supporting Architecture	0.9.2	06-184r2	2007-08-14
Geographic information - Rights expression language for geographic information - Part xx: GeoREL	0.9.0	06-173r2	2007-01-25
GEOINT Structure Implementation Profile (GSIP) Schema Processing	0.5.0	07-028r1	2007-05-17
Geolinked Data Access Service	0.9.1	04-010r1	2004-05-04
Geolinking Service	0.9.1	04-011r1	2004-05-04
Geospatial Portal Reference Architecture	0.2.0	04-039	2004-09-22
Geospatial Semantic Web Interoperability Experiment Report	0.5.0	06-002r1	2006-08-21
GML Performance Investigations by CubeWerx	1.0.0	05-050	2006-05-02
GML Point Profile	0.4.0	05-029r4	2005-08-29
Grid Coverage Coordinate Reference Systems	0.3.2	09-085r2	2009-10-13
Imagery Metadata	1.0.0	05-015	2005-01-27
Local MSD Implementation Profile (GML 3.2.1)	0.7.0	07-027r1	2007-05-25
OGC Catalogue Services – OWL Application Profile of CSW	0.3.0	09-010	2009-07-27
OGC Cataloguing of ISO Metadata (CIM) using ebRIM profile of CS-W	0.1.7	07-038	2007-06-06
OGC Loosely Coupled Synchronization of Geographic Databases in the Canadian Geospatial Data Infrastructure Pilot	0.0.9	08-001	2008-04-29
OGC CGDI WFS and GML Best Practices ER	1.0.0	08-002	2008-04-29
Geo-Synchronization Service	0.1.0	08-003	2008-05-14
OGC Web Services (OWS) 3 UML to GML Application Schema (UGAS) Tool	0.0.3	05-118	2006-04-28
OGC Web Services Architectural Profile for the NSG	1.3.0	07-009r3	2007-08-13
OGC Web Services Architecture for CAD GIS and BIM	0.9.0	07-023r2	2007-05-16
OpenGIS Sensor Event Service Interface Specification	0.3.0	08-133	2008-10-10
OpenSearch Geospatial Extensions Draft Implementation Standard	0.0.1	09-084r1	2009-10-13
OWS 3 GML Investigations - Performance Experiment by Galdos Systems	-	05-101	2006-04-19
OWS-5 Conflation Engineering Report	0.1.0	07-160r1	2008-09-12
OWS-5 Data View Architecture ER	0.0.0	07-163	2008-05-02
OWS-5 Earth Observation Web Processing Services ER	0.1.0	08-058r1	2008-09-12
OWS-5 Engineering Report on WCPS	0.9.0	07-166r2	2008-08-04
OWS-5 GeoRM License Broker Specification ER	0.9	08-076	2008-09-12
OWS-5 GSIP Schema Processing ER	0.0.3	08-078r1	2008-07-08
OWS-5 KML Engineering Report	0.1.0	07-124r2	2008-09-12
OWS-5 Local MSD Profile	0.0.2	08-077	2008-05-15
OWS-5 SOAP/WSDL Common Engineering Report	0.1.0	08-009r1	2008-02-21

Title	Version	Document #	Date
OWS-5 OGC Web Feature Service, core and extensions	0.9.0	08-079	2008-09-12
Integrated Client for Multiple OGC-compliant Services	0.1.18	03-021	2003-01-20
OWS Integrated Client (GeoDSS Client)	0.0.3	05-116	2007-03-08
OWS Messaging Framework	-	03-029	2003-01-20
OWS-2 Application Schema Development	0.0.4	04-100	2005-04-13
OWS-3 GML Topology Investigation	-	05-102r1	2006-05-09
OWS-3 Imagery Workflow Experiments: Enhanced Service Infrastructure Technology Architecture and Standards in the OWS-3 Testbed	0.9.0	05-140	2006-03-30
OWS4 - Topology Quality Assessment Interoperability Program Report	0.3.0	07-007r1	2007-06-06
OWS-4 CSW ebRIM Modelling Guidelines IPR	-	06-155	2007-06-06
Requirements for some specific simple solid, plane and line geometry types	0.5.0	07-001r3	2007-05-02
Schema Maintenance and Tailoring	0.0.7	05-117	2006-05-02
Semantic annotations in OGC standards	0.3.0	08-167r1	2009-07-16
Sensor Observable Registry Discussion Paper	0.3.0	09-112	2009-10-13
Some image geometry models	1.0.0	04-071	2004-10-04
Specification of the Sensor Service Architecture (SensorSA)	3.1	09-132r1	2009-10-02
Temporal Standard Recommendations	-	06-022r1	2006-04-21
Trusted Geo Services IPR	0.9.0	06-107r1	2007-05-07
Uncertainty Markup Language (UnCertML)	0.6	08-122r2	2009-04-08
Web 3D Service (W3DS)	0.3.0	05-019	2005-02-02
Web Coordinate Transformation Service (WCTS)	0.4.0	07-055r1	2007-10-09
Web Coverage Processing Service (WCPS)	-	06-035r1	2006-05-02
Web Coverage Service (WCS) 1.1 extension for CF-netCDF 3.0 encoding	0.2.2	09-018	2009-04-08
Web Image Classification Service (WICS)	0.3.3	05-017	2005-02-10
Web Object Service Implementation Specification	0.0.3	03-013	2003-01-15
Web Services Architecture	0.3.0	03-025	2003-01-18
Web Services Summaries	0.3.0	07-095r2	2007-11-14
WFS Temporal Investigation	0.1.0	06-154	2007-08-14
WMS - Proposed Animation Service Extension	0.9.0	06-045r1	2006-07-27
WMS Change Request: Support for WSDL & SOAP	0.1.0	04-050r1	2005-04-22
WMS Part 2: XML for Requests using HTTP Post	-	02-017r1	2002-08-24
Workflow Descriptions and Lessons Learned	0.0.9	06-187r1	2007-05-07
Wrapping OGC HTTP-GET/POST Services with SOAP	0.1.0	07-158	2008-01-02
XML for Image and Map Annotation	0.4.0	01-019	2001-02-06

3.6 Non-OGC Standards Related to OWS-7

These are placed here for reference-specific requirements mentioned in some of the threads. These are not all required or normative.

Table 3-6. Non-OGC Standards Related to OWS-7

Name	Specification	Description
WSDL	Web Services Description Language v 2.0 W3C Recommendation http://www.w3.org/TR/wsdl20/	Web Services Description Language (WSDL) is a specification from W3C to describe networked services. WSDL is used to describe what a web service can do, where it resides, and how to invoke it. It provides a simple way for service providers to describe the basic format of requests to their systems.
SOAP	Simple Object Access Protocol (SOAP) 1.1 http://www.w3.org/TR/soap11/ ; SOAP 1.2 http://www.w3.org/TR/soap/	Simple Object Access Protocol (SOAP) is a protocol specification from W3C for exchange of information in a decentralized, distributed environment.
BPEL	Web Services Business Process Execution Language 2.0 – OASIS Standard http://docs.oasis-open.org/wsbpel/2.0/wsbpel-v2.0.html	The Business Process Execution Language for Web Services (BPEL4WS or BPEL for short) defines a notation for specifying business process behavior based on Web Services.
ebXML	OASIS Standard 2.0 http://www.oasis-open.org/specs/index.php#ebxmlbp2.0.4 , see also ISO/TS 15000-5:2005	Defines a standards-based business process foundation that promotes the automation and predictable exchange of Business Collaboration definitions using XML.
ebXML RIM	ebXML Registry Information Model 2.0 – OASIS Standard http://www.oasis-open.org/committees/regrep/documents/2.0/specs/ebrim.pdf	Defines what information is in the Registry and how that information is organized. This leverages as much as possible the work done in the OASIS and the ISO 11179 Registry models.
BPMN	Business Process Modeling Notation 1.1 - OMG Specification http://www.bpmn.org/	Provides businesses with the capability of understanding their internal business procedures in a graphical notation and will give organizations the ability to communicate these procedures in a standard manner.

Name	Specification	Description
Wf-XML	Workflow-XML 1.1 and 2.0 - Workflow Management Coalition (WfMC) Standard http://www.wfmc.org/standards/wfxml.htm	Wf-XML is designed and implemented as an extension to the OASIS Asynchronous Service Access Protocol (ASAP). ASAP provides a standardized way that a program can start and monitor a program that might take a long time to complete. Wf-XML provides additional standard web service operations that allow sending and retrieving the "program" or definition of the service which is provided. Wf-XML is an ideal way for a BPM engine to invoke a process in another BPM engine, and to wait for it to completed.
Wf-XML-R	Workflow-XML (RESTful Binding) Draft 0.4 - WfMC Standard http://www.wfmc.org	
XPDL	XML Process Definition Language 2.1 – WfMC Standard http://www.wfmc.org/standards/xpdl.htm	XPDL provides a file format that supports every aspect of the BPMN process definition notation including graphical descriptions of the diagram, as well as executable properties used at run time.
CAP-V1.1	Common Alerting Protocol 1.1 – OASIS Standard http://www.oasis-open.org/committees/download.php/15135/emergency-CAPv1.1-Corrected_DOM.pdf	The Common Alerting Protocol (CAP) is a simple but general format for exchanging all-hazard emergency alerts and public warnings over all kinds of networks.
WS-Addressing	Web Services Addressing – W3C Recommendation, http://www.w3.org/TR/ws-addr-core, and SOAP binding, http://www.w3.org/TR/ws-addr-soap	Web Services Addressing provides transport-neutral mechanisms to address Web services and messages.
WS-Coordination	Web Services Coordination 1.1 – OASIS Standard http://docs.oasis-open.org/ws-tx/wstx-wscoor-1.1-spec/wstx-wscoor-1.1-spec.html	The WS-Coordination specification describes an extensible framework for providing protocols that coordinate the actions of distributed applications.
WS-Atomic Transaction	Web Services Atomic Transaction 1.1 – OASIS Standard http://docs.oasis-open.org/ws-tx/wstx-wsat-1.1-spec.pdf	This specification provides the definition of the Atomic Transaction coordination type that is to be used with the extensible coordination framework described in WS-Coordination.
WS-Eventing	W3C submission http://www.w3.org/Submission/WS-Eventing/	Describes a protocol that allows Web services to subscribe to or accept subscriptions for event notification messages. This is a public draft for review and evaluation only.

Name	Specification	Description
WS-Notification	Web Services Notification 1.3 OASIS Standard http://www.oasis-open.org/committees/documents.php?wg_abbrev=wsn	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".
WS-Topic	Web Service Topic – OASIS Standard http://docs.oasis-open.org/wsn/wsn-ws_topics-1.3-spec-os.pdf	Part of WS-Notification
WS-Policy	Web Services Policy – W3C Recommendation http://www.w3.org/TR/ws-policy	The Web Services Policy Framework provides a general purpose model and corresponding syntax to describe the policies of entities in a Web services-based system.
WS-Federation	Identity Federation specification v1.1, http://www.ibm.com/developerworks/library/specification/ws-fed/	Defines mechanisms for allowing disparate security realms to broker information on identities, identity attributes and authentication.
WS-Reliable Messaging	Reliable Messaging 1.1 – OASIS Standard http://docs.oasis-open.org/ws-rx/wsrm/200702/wsrm-1.1-spec-os-01.pdf	Describes a protocol that allows SOAP messages to be delivered reliably between distributed applications in the presence of software component, system, or network failures.
WS-Security	Web Services Security 1.1 – OASIS Standard http://www.oasis-open.org/committees/download.php/16790/wss-v1.1-spec-os-SOAPMessageSecurity.pdf	This specification and associated token profiles (Username, X.509, SAML, Kerberos, REL, and SOAP with Attachments) provide the technical foundation for implementing security functions such as integrity and confidentiality in messages implementing higher-level Web services applications.
WS-Trust	Web Services Trust 1.3 – OASIS Standard http://docs.oasis-open.org/ws-sx/ws-trust/v1.3/ws-trust.html	This specification defines extensions that build on [WS-Security] to provide a framework for requesting and issuing security tokens, and to broker trust relationships.
SAML	Security Assertion Markup Language 1.1 – OASIS Standard http://www.oasis-open.org/specs/index.php#samlv1.1 SAML 2.0 – OASIS Standard http://www.oasis-open.org/specs/#samlv2.0	This specification defines the syntax and semantics for XML-encoded assertions about authentication, attributes, and authorization, and for the protocols that convey this information.
XACML	eXtensible Access Control Markup Language 2.0 – OASIS Standard http://www.oasis-open.org/specs/#xacmlv2.0	This specification, together with associated schemas and resource profiles, defines the syntax and semantics for access control.

Name	Specification	Description
XML Digital Signature	W3C Recommendation http://www.w3.org/TR/xmldsig-core/	Specifies XML digital signature processing rules and syntax. XML Signatures provide integrity, message authentication, and/or signer authentication services for data of any type, whether located within the XML that includes the signature or elsewhere.
XML Encryption	W3C Recommendation http://www.w3.org/TR/xmlenc-core/	Specifies a process for encrypting data and representing the result in XML. The data may be arbitrary data (including an XML document), an XML element, or XML element content.
PKI	Public Key Infrastructure – IETF Standard http://www.ietf.org/html.charters/pkix-charter.html	Internet standards to support X.509-based Public Key Infrastructures (PKI) for data encryption.
XKMS	XML Key Management System – W3C Note http://www.w3.org/TR/xkms/	Specifies protocols for distributing and registering public keys, suitable for use in conjunction with the proposed standard for XML Signature. This document is a NOTE made available by the W3C for discussion only.
UncertML	Uncertainty Markup Language: http://www.intamap.org/pub/UncertML.pdf http://wiki.intamap.org/index.php/INTAMAP_Wiki	XML vocabulary for communicating about uncertainty.
RSS 2.0	Web syndication system http://www.rssboard.org/rss-specification	RSS is a family of Web feed formats to publish frequently updated content.
Atom 1.0	Atom Syndication Format is IETF RFC 4287 http://tools.ietf.org/html/rfc4287 while Atom Publishing Protocol is IETF RFC 5023 http://tools.ietf.org/html/rfc5023	Alternative to RSS to ease the development of applications with web syndication feeds.
GeoRSS GML	Geographically Encoded Objects for RSS Feeds as GML Application Schema, http://georss.org/gml	Encoding of GeoRSS' objects in a simple GML version 3.1.1 profile. Compatible with RSS and Atom.
ISO 19117:2005	ISO TC211 Document n1578 http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=40395	Geographic Information - Portrayal
Motion Imagery Standards Profile	Motion Imagery Standards Profile (MISP) Version 5.3 3 September 2009 http://www.gwg.nga.mil/misb/docs/MISP53.pdf	Department of Defense/Intelligence Community/ National System for Geospatial Intelligence (DoD/IC/NSG) Motion Imagery Standards Board
ISO/IEC 21000-5: 2004/Amd 2:2007	Rights Expression Language, REL http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=44341	ISO/IEC 21000-5:2004 specifies the syntax and semantics of a Rights Expression Language.

Name	Specification	Description
ISO/IEC 15408: 2005	Part 1 - http://standards.iso.org/ittf/PubliclyAvailableStandards/c040612_ISO_IEC_15408-1_2005(E).zip ; Part 2 - http://standards.iso.org/ittf/PubliclyAvailableStandards/c040613_ISO_IEC_15408-2_2005(E).zip ; Part 3 - http://standards.iso.org/ittf/PubliclyAvailableStandards/c040614_ISO_IEC_15408-3_2005(E).zip	Information technology – Security techniques – Evaluation criteria for IT security.
ISO/IEC TR15443: 2005	Information technology -- Security techniques -- A framework for IT security assurance http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=39733	Technical Report to guide the IT security professional in the selection of an appropriate assurance method when specifying, selecting, or deploying a security service, product, or environmental factor such as an organization or personnel.
ISO/IEC 10181: 1996	ISO catalogue link for ordering: http://www.iso.org/iso/search.htm?qt=10181&published=on&active_tab=standards	Security Framework for Open Systems; Part 1-Overview, Part 2-Authentication framework, Part 3-Access control framework, Part 4-Non-repudiation framework, Part 5-Confidentiality framework, Part 6-Integrity framework, Part 7-Security audit and alarms
ISO 19134	ISO/TC211 N2045, 2006-07-17 – Geographic Information – Location based services – Multimodal routing and navigation	This International Standard provides a conceptual schema for describing the data and services needed to support routing and navigation application for mobile clients who intend to reach a target position using two or more modes of transportation.
INFOD	www.ogf.org	Open Grid Forum (OGF) specification for metadata registry system for use in grid computing.
CSM TRD	Community Sensor Model (CSM) Technical Requirements Document (TRD) from Community Sensor Model Working Group (CSMWG), http://www.csmwg.seicorp.com/CSM2Doc.htm	The CSM Program will provide Government and Industry with the capability to create and maintain a standard program for developing, testing, and evaluating a collection of current and future sensor models. The models support Sensor Exploitation Tools (SETs) and other application tools that require a precise understanding of the image (data) and ground coordinate relationships. The CSMs are dynamically linked (or loaded) libraries that do not require re-compilation of the SET.

4 OWS-7 Architecture

4.1 Fusion Standards Pre-Study

Reference: Fusion Standards Study Engineering Report, OGC Document 09-138, draft 02 October 2009. 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 conducted in the summer of 2009, to help determine the requirements to be met in OWS-7. More broadly, the goal of this study was to define and develop fusion standards to give analysts an environment in which to use interoperable tools to analyze, process and exploit two or more 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.

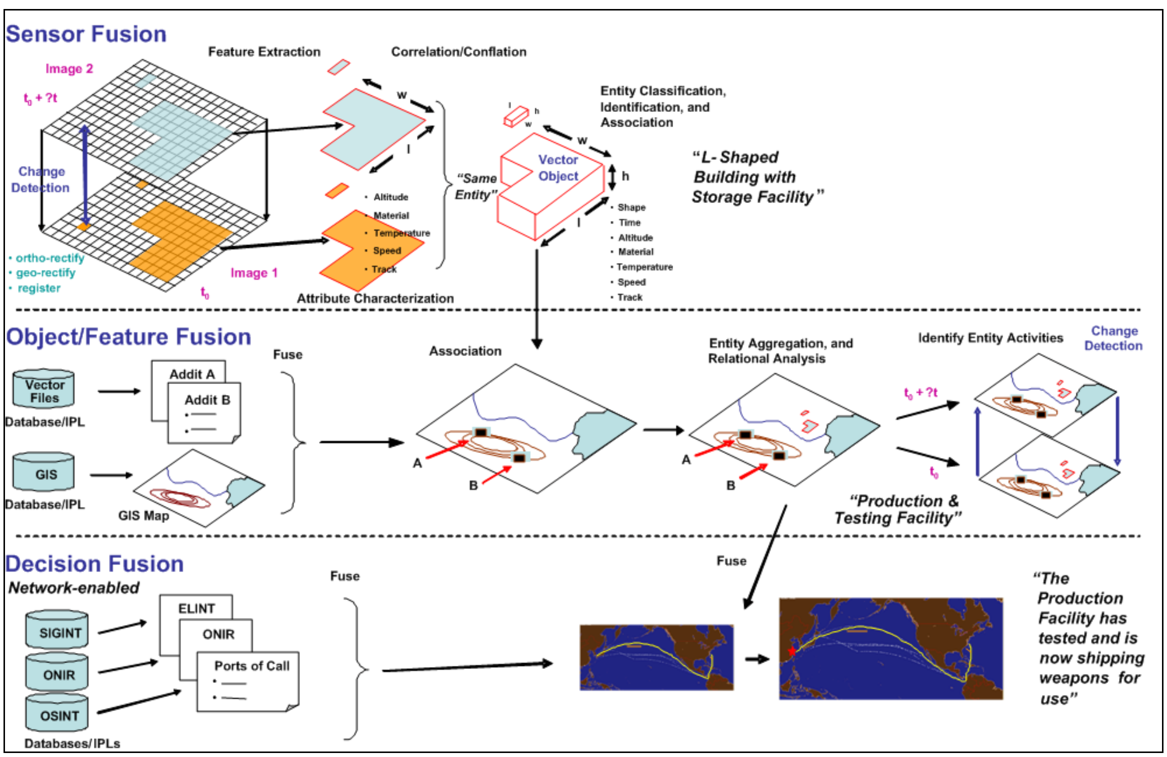

Figure 4-1. Categories of Fusion

The three categories of Fusion used in this Engineering Report are:

- 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.

4.1.2 Fusion Recommendations

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

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 initiative threads. What was previously called the Sensor Web Enablement thread is now being called the Sensor Fusion Enablement (SFE) thread, to reflect its change in emphasis for OWS-7. The previous Geo-Processing Workflow and Decision Support Services threads are now being combined into a single Feature and Decision Fusion (FDF) thread. The main reason for combining these is to improve communications between developers of the Integrated Client (the centerpiece of decision support services) and developers of the workflow processes. These changes in thread organization are shown in Figure 2-2, page 9.

The Aviation Thread was not considered directly in the Fusion Standards Study, but will benefit 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.

4.1.3 Fusion Standards Study, Phase 2

A second phase of the Fusion Standards Study will be conducted in parallel with the OWS-7 Testbed. Phase 2 of the study will elaborate on Decision Fusion. The focus will be on documenting research, techniques and implementations, and lessons learned about decision fusion for multi-INT. A scenario will be developed based on evaluation of integrating data and information from multiple intelligence sources. This scenario shall take into account the requirements for multi-level security, the exchange of information between analysts and in-the-field forces, appropriate metadata tagging to include the life-cycle of data from collection to update to fusion. The OWS-7 H1N1 Virus Outbreak Response scenario (Section 4.3.5.2) will inform the Phase 2 Fusion scenario. A Fusion Standards Study, Phase 2 Engineering Report will be written by OGC staff, with input from participants and sponsors as appropriate.

4.2 Sensor Fusion Enablement (SFE) Thread

4.2.1 SFE Background

As a thread of activity in OWS-7, Sensor Fusion Enablement (SFE) 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 SFE 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.

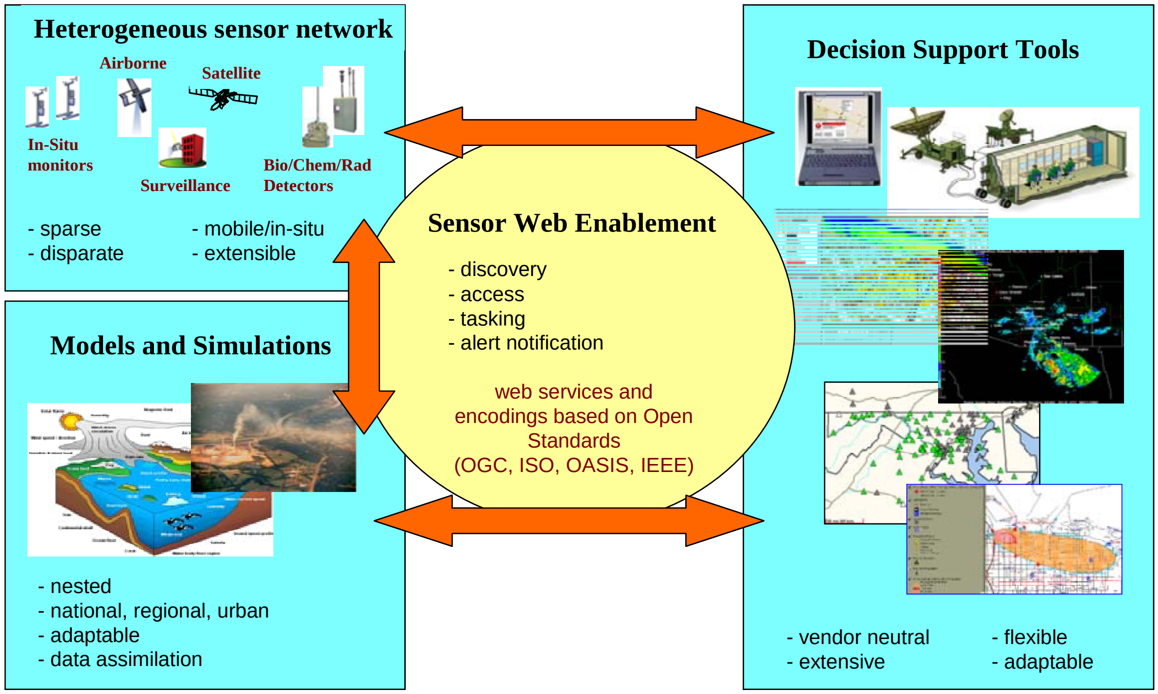

Figure 4-2. The Role of SWE

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-7:

1. Discovery and access of dynamic sensors

It is vital for timely recognition of situation awareness that we are able to readily discover and access information about dynamic sensor assets that might be useful for us, to access observations or receive alerts from these systems in a readily meaningful and usable encoding, and to easily task these systems to provide much needed observations in order to fill gaps in our knowledge. Currently, timely discovery and access to highly dynamic assets is currently challenging at best. Investigating alternatives for improving rapid discovery and access to highly-dynamic sensors are encouraged, including investigations into non-traditional technologies such as P2P and the query of web services that are closer upstream to the sensor system.

2. Characterizing and propagating uncertainty of measurements

All measured and processed results include a certain degree of uncertainty. No measurement, no recognition of an object or event, and no determination of an object's properties are free from possible error and uncertainty. Errors and uncertainty can arise from inevitable limitations in the sensor systems, from errors introduced or propagated during the processing of the data, or in act of comparing observations with signatures taken under varying environmental conditions. Thus, while it is important to minimize uncertainty, recognizing the amount of uncertainty in a result is equally important. It is recommended that efforts be taken to define terms of uncertainty, to insure the inclusion of values of uncertainty within sensor and observations metadata, and to determine algorithms for propagating error through processing algorithms or workflows.

3. Fusion of video from airborne and ground based platforms

Video 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 video 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 geometric 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.

4. 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 SFE Scope

The Sensor Fusion Enablement (SFE) Thread builds on the OGC Sensor Web Enablement framework that has achieved a degree of maturity through previous OWS interoperability initiatives and deployments worldwide. OWS-7 will focus on integrating the SWE interfaces and encodings with workflow and web processing services to achieve sensor fusion. SFE will continue the development of Secure SWE architecture. And OWS-7 SFE will continue the interoperability of SWE and CCSI.

Emphasis for SFE during this phase of the OWS testbed will be on the following:

- Motion Video Fusion. Geo-location of motion video for display and processing. Change detection of motion video using Web Processing Service with rules.
- Dynamic Sensor Tracking and Notification. Track sensors and notify users based on a geographic Area of Interest (AOI). The sensor and the user may be moving in space and time.

- Trusted SWE in an untrusted environment. Build on OWS-6 Secure Sensor Web development, to investigate secure SOS, SPS in more depth
- CCSI-SWE Best Practice. Building on OWS-6, develop an ER to be considered by the OGC Technical Committee as a Best Practice.

4.2.3 SFE Requirements

4.2.3.1 Motion Video Fusion

OWS-7 will evaluate OGC standards capabilities for interoperability of Motion Video. Specifically, evaluation of OGC compliant client(s) capability to view Motion Imagery, add and embed Motion Imagery metadata allowing for an embedded visual display of the Motion Imagery and its associated metadata. OWS-7 will develop the ability to tag a geolocation with Motion Imagery for discovery, retrieval and linkage with other data sources over the same location.

Develop and document within a combined Motion Imagery Discovery and Retrieval ER the process for Motion Imagery metadata, discovery, and retrieval.

Investigate and experiment with Change Detection capabilities for Motion Imagery. Deploy rules-based Change Detection service with the ability through a client interface to modify and/or enhance rules based on in the field conditions. Implemented solutions should be able to identify changes between two motion images over the same geographic location. For example, Change Detection between two videos taken as a vehicle passes along a road should highlight areas of new debris on the side of a road, significant soil coloration changes, etc. This will require the ability to discover and retrieve previously recorded and stored motion imagery. Rules will be required to account for such elements as differences in weather or time of day between the two videos.

Uncertainty of the Change Detection results will be predicted as part of the calculation process. Uncertainty of the input motion video streams will be a basis for the propagation of uncertainty in to the change detection algorithm result.

OWS-7 will develop and document within a Motion Imagery/Change Detection Engineering Report both service development and client aspects for change detection rules creation, metadata capture and display.

4.2.3.2 Dynamic Sensor Tracking and Notification

OWS-7 will develop the ability to track sensors and notify users based on a geographic Area of Interest (AOI). In this context, tracking means receiving updates of the sensors position and field of view. AOI can be identified as a geographic point, a geographic area, a bounding box or possibly a placename. Investigate and experiment with dynamic sensors to include the ability to determine the presence of absence of sensors over or within an AOI, the timeframe when a sensor may become available over a specific AOI and the field of view for those sensors. A SOAP-based, access-restricted OGC service should be implemented in order to track the sensors and to ensure notification is granted based on user profiles and requirements for access. The service must provide the ability for a user to identify an AOI, subscribe for notification of sensor availability and receive streaming data as it becomes available by connecting to an access service. For the subscription and notification capabilities consideration should be given to the roles of Sensor Alert Service, Web Notification Service, OASIS Common Alerting Protocol, and the OWS-6 Event Architecture. But it is not certain that the existing services are suitable so other technologies may be considered, e.g., dynamic routing technology based in hardware for streaming notification (See the Fusion Standards Study ER.)

Develop and document within a Dynamic Sensor Notification Engineering Report the process for securing dynamic sensor tracking. Include within this ER documentation of the process of subscribing and receiving notifications/alerts based on AOI (location) and temporal requirements.

4.2.3.3 Trusted SWE in an untrusted environment

This requirement builds on the OWS-6 results of developing open standards for secure sensors web services. These standards are needed for projects within multinational environment with security & confidentiality aspects as well as multi-trust levels to be elaborated and finally realized.

OWS-7 will develop of methods to provide secure access to OGC Sensor Web Enablement Services: Sensor Observation Service, (SOS), Sensor Alert Service (SAS), Web Notification Service (WNS), Sensor Planning Service (SPS) with the EO extension, and SPS in general. Specific requirements include:

- Authentication for establishing secure communication with SWE Services and associate access rights to users and clients
- Secure communication including message layer and network layer security
- Geo-specific Attribute Based Access Control (ABAC) for SWE Services to ensure appropriate functioning and information flow control for requests and responses
- Trust to SWE Services, in particular SPS and SAS to ensure that the alert can be trusted. This feature is very important because severe consequences can be caused by an alert.
- Alerts from SAS/WNS must be delivered to registered (interested) clients. It is important to reach clients in particular behind firewalls! Hence, Integrity & Confidentiality of messages and insurance of message delivery (reliable messaging) is required.
- Trusted auditing for all communication between secure SWE services
- Non-repudiation for all communication between secure SWE services.
- Secure SWE Services must advertise the requirements to execute service and secure messages: (i) how must requests be secured to be accepted by SAS? (ii) How will responses be secured?

For the Sensor Planning Service an implementation shall be demonstrated that meets these requirements.

Develop an OGC Interoperability Program Engineering Report that shall include at least following information:

- A refined use case including alternative scenarios where security issues are tackled.
- Detailed technical architecture

- Technical guidance for procurement
- Recommendations for specification development in OGC Technical Committee
    - Introduce results into standardisation process and provide
    - Recommendations for a "Secure Sensor Web", i.e. change requests to existing specs such as SPS with its EO profile, SOS, SAS, WNS etc.

4.2.3.4 CCSI-SWE Best Practice candidate

This requirement builds on a previous requirement from OWS-6. In OWS-6 the result was a demonstration of a CCSI to Sensor Web Enablement (SWE) service translator, the Sensor Interface Service (SIS). In OWS-7 the requirement is to develop an Engineering Report that will be offered to the OGC Technical Committee for consideration as a Best Practice. The CCSI-SWE Best Practices ER will refine and validate the mappings between CCSI and SWE messages, evaluate them to determine how much real alignment there is in content, and provide alternatives for migrating CCSI to a SWE specification. Some anticipated alternatives for consideration include topics such as:

- Embedding the SIS into the sensor or SWE service
- Proposing the SIS as an OGC standard
- Establishing a catalog and library of certified SIS software.

The following tasks shall be performed in support of this requirement:

1. Map CCSI messages to SWE messages – Beginning with an initial mapping from the JPEO-CBD Software Support Activity (SSA) develop the mapping of CCSI to SWE messages.
2. Map the CCSI sensor definition file to SensorML – Refine and verify the mapping of the CCSI sensor definition file to SensorML.
3. Map the CCSI architecture to appropriate SWE architectures
4. Develop alternatives and recommendations for integrating CCSI into OGC standards. Alternatives to include a feasibility analysis indicating the value of the alternatives.
5. Develop an Engineering Report using OGC guidelines for Best Practices Papers.

4.2.4 SFE Deliverables

The OWS-7 SFE thread requires two types of deliverables:

- **Engineering Reports and Documents**: 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-7" in the title, to facilitate later literature searches.

- **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.

4.2.4.1 SFE Engineering Reports (ERs) and Documents

The following Engineering Reports (ERs) and Schemas will be developed in the SFE thread and submitted to the OGC Specification Program at the completion of the OWS-7 Testbed.

Table 4-1. SFE Engineering Reports Required

1) OWS-7 Motion Imagery Discovery and Retrieval ER. Document the metadata used to tag geolocation of Motion Imagery for discovery, retrieval and linkage with other data sources over the same location.
2) OWS-7 WPS Change Detection ER. Develop and document an Engineering Report the process for Motion Imagery Change Detection as a profile of WPS. Discussion of uncertainty propagation from inputs to outputs. ER will discuss service development and client aspects for change detection rules creation, metadata capture and display. The Change Detection WPS will be developed in tandem with the WPS Profiling ER.
3) OWS-7 Dynamic Sensor Notification ER. Document the process for notification of Sensor tracks and locations based on temporal requirements. Include within this ER documentation of the process of subscribing and receiving notifications based on AOI.
4) OWS-7 Secure Sensor Web Architecture ER. ER to included a refined use case, detailed technical architecture, technical guidance for procurement and recommendations for specification development in OGC Technical Committee
5) OWS-7 CCSI-SWE Best Practices ER. Includes mappings between CCSI and SWE specification elements (messages and SensorML), discussion of the degree of alignment of the mappings, and alternatives for migrating CCSI to a SWE specification.
6) OWS-7 SWE Change Requests (SPS/EO, SOS, SAS, WNS, etc. as needed)

4.2.4.2 Services, Clients and Tools

Implementations of the following services, tools and data instances will be developed in this OWS-7 thread, tested in Technology Integration Experiments (TIEs) and invoked for cross-thread scenarios for OWS-7 demonstration events:

Table 4-2. SFE Services, Clients and Tools Required

1) SOS secure server for Motion Imagery (dynamic sensor).	Service
2) WPS server for Change Detection (rules, JPG/GMLJP2). Change Detection WPS will compare two videos (to be provided by Participants, not GFI) of the same region from an SOS. Algorithm to highlight areas of new debris on the side of a road, significant soil coloration changes, etc. Including	Service

propagation of uncertainty.	
3) Tracking and notification service. The RFQ seeks innovative proposals for how to meet the function of dynamic sensor tracking and notification functions. Service should be SOAP-based and access restricted. 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) SPS EO Profile Server for Motion Imagery sensor (secure, dynamic).	Service
5) Security infrastructure component (certificate authority)	Service
6) Motion Video Sensor Schema	Schema
7) SFE Client (secure, motion video, dynamic sensor, change detection with rules)	Client
8) One or more CCSI Sensors accessible using SWE interfaces for use in SFE demonstration scenario	Service

4.2.5 SFE 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.

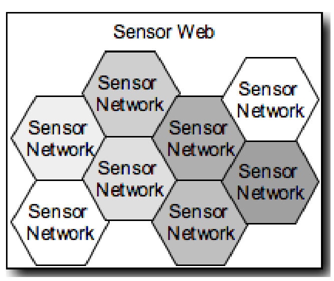

Figure 4-3. Sensor Web: Aggregation of Sensor Networks

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 SFE 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.

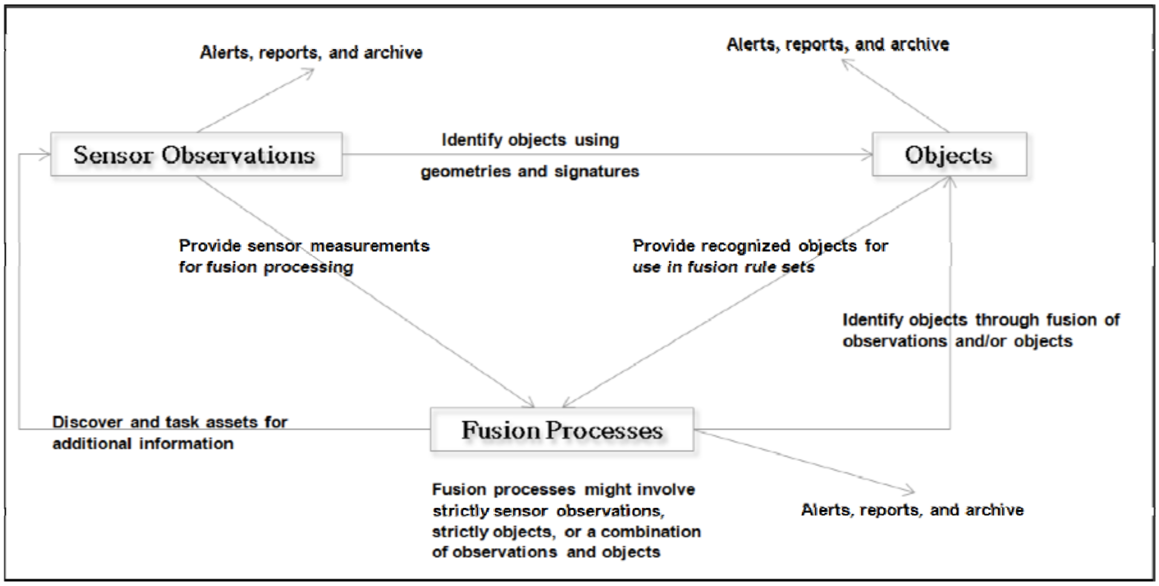

Figure 4-4. Sensor Fusion processes

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 Secure Sensor Web

Secure Sensor Web applies standards-based security solutions for making the SWE baseline ready for the handling of sensors in the intelligence domain. This brings in the requirement for handling sensors that eventually produce classified information and the main objective of accreditation.

Requirements for secure sensor webs are based on the Trusted Computer System Evaluation Criteria (TCSEC), A Security Architecture for Net-Centric Enterprise Services (NCES), the Internet Threat Model, as defined in IETF RFC 3552, and ISO 10181, “Security Frameworks for Open System."

4.2.5.4 SFE Enterprise Use Case for OWS-7

4.2.5.4.1 Motion Imagery Change Detection Use Case

The Enterprise Viewpoint use case presented below focus on secure access to motion imagery provided by a dynamic sensor in an unsecured environment. The recent motion imagery is used with previous imagery of the same location to determine any changes.

<table>
<tr><td>Use Case Identifier: SFE #1</td><td colspan="2">Use Case Name: Change Detection in Motion Imagery</td></tr>
<tr><td colspan="2">Use Case Domain: OWS-7 SFE</td><td>Status: Draft 2009-10-28</td></tr>
<tr><td colspan="3">Use Case Description: Motion imagery from a vehicle-mounted camera is compared with a previous motion imagery record to determine changes between the two observations along the vehicle track. This scenario includes use of motion imagery metadata and a change detection algorithm applied to the two motion imagery instances including an estimate of the uncertainty. CCSI sensors, if available, are accessed for additional information.</td></tr>
<tr><td>Actors (Initiators):

Crew on-board a ground vehicle equipped with video camera</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.

CCSI sensor has been deployed.</td><td colspan="2">Post-Conditions:

Changes in the AOI are detected and presented to the user with an estimate of the uncertainty.

UGS measurements in the AOI are available through SOS-CCSI</td></tr>
<tr><td colspan="3">System Components:

1) SOS for Motion Imagery from a camera on a moving ground vehicle.
2) SOS for Motion Imagery previously acquired from ground vehicle.
3) WPS server for Change Detection algorithm
4) CCSI Sensors with SWE interfaces (if available)
5) Sensor tracking and notification service
6) SFE Client in ground vehicle</td></tr>
<tr><td colspan="3">Basic Course of Action:

1. Ground vehicle equipped with video camera enters an area of interest (AOI) and is</td></tr>
</table>

acquiring motion imagery.

2. As the AOI was previously identified as a potential risk zone, the entry of the vehicle into the AOI triggers an event. The action associated with the event is to begin a change detection process on the imagery.
3. Activity of the Service for sensor tracking and notification results in the WPS for Change Detection to begin.
4. WPS begins change detection on live motion imagery stream and previously acquired imagery from the same AOI.
5. Initial WPS results are made available to the SFE client in the vehicle. Potential but unconfirmed changes were detected and are made available to the crew along with an estimate of the uncertainty of the changes detected.
6. Crew reviews the initial results of the Change Detection and determines that parameters in the rules should be changed to account for such elements as differences in weather or time of day between the two videos.
7. WPS Change Detection is performed again with the new rule parameters. Resulting change detection highlights areas of new debris on the side of a road, significant soil coloration changes, etc. Uncertainty of the second result is less than the first.
8. Crew changes the vehicle route based upon change detection results.

(Optional step can be added above would be to include access to CCSI sensors located in the AOI to provide additional information about the changes in the AOI.)

4.2.5.4.2 Secure SPS Enterprise Use Case

The use case describes the scenario for requesting image acquisition from a space-based sensor using an untrusted network for communication, receiving status notifications and retrieving respective.

Use Case Identifier: SFE #2	**Use Case Name**: Secure SPS
Use Case Domain: OWS-7 SFE	**Status**: Draft 2009-10-16
Use Case Description: The use case describes a scenario for requesting image acquisition from a space-based sensor using an untrusted network for communication, receiving status notifications of the imagery acquisition and retrieving the acquired imagery .	
Actors (Initiators): - Operator - Space Operations Centre (SOC) - Data Centre	**Actors (Receivers):** Same as initiator
Pre-Conditions:	**Post-Conditions**:

- The entire communication for execution of the request, receiving messages/notifications and access to observations must be secured. - Access must be protected to all sensor web services.	Trusted auditing of all communication shall be possible.

System Components:

1) SPS EO Profile Server for Motion Imagery sensor
2) Security infrastructure component (certificate authority)
3) SFE Client

Basic Course of Action:

This UC starts at when a new acquisition is necessary to provide up-to-date data for a specific area of interest.

1. An operator submits a request to a satellite-imaging sensor in a multinational environment via a SPS provided by a SOC.
2. After successful feasibility testing image acquisition is performed.
3. Data is downlinked and stored in the data centre.
4. The operator is notified that data is available.
5. The operator retrieves the data from the repository.

Success Guarantee:

The use case provides the opportunity to acquire satellite data by trusted procedures in an untrusted environment.

Additional Information:

Different security domains exist secured by Demilitarised Zones. Operator, SOC and Data centres are in different DMZ.

All communication and data transport, e.g. delivery of messages and products, shall be reliable.

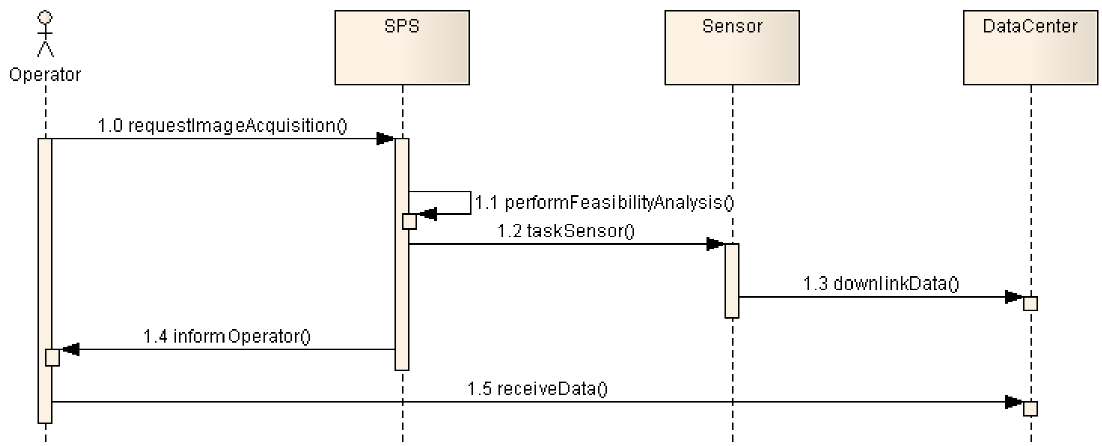

Figure 4-5. Secure SWE use case

4.2.6 SFE 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.

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 SWE Common

References:

- *Sensor Model Language (SensorML) Implementation Specification, OGC document 07-000*
- *SensorML CR – Separate SWE Common Specification, OGC document 08-147*
- *OWS-6 SWE Information Model ER, OGC Document 09-031r1*

The primary focus of the SWE Common Data Model is to define and package sensor related data in a self-describing and semantically enabled way. The main objective is to obtain interoperability, first at the syntactic level, and later at the semantic level (by using ontologies and probably semantic mediation) so that sensor data can be better understood by machines, processed automatically in complex workflows and easily shared between intelligent sensor web nodes.

The current version of the SensorML specification includes specification of the SWE Common data model specification. It was recognized during the release of Version 1.0, that the SensorML and SWE Common specifications should be treated as separate specification with separate documents in future releases. The SWE Common SWG is currently working on this for the SWE Common 1.1 specification. The next release of SensorML should reflect that change as well.

SWE Common knows a number of fundamental types that derive from the *AbstractDataComponent* (which is derived from *gml:AbstractGMLType*, i.e. it implements abstract-types of the *Geography Markup Language, GML*).
The OWS-6 SWE Information Model ER discusses relations between SensorML, SWE Common and GML and investigates solutions for increased synergy between them. The effort has been supported by UML models of the data types used in SWE and GML.

4.2.6.2 Sensor Model Language (SensorML)

References:

- *Sensor Model Language (SensorML) Implementation Specification, OGC document 07-000*
- *OWS-6 SensorML Profile for Discovery ER, OGC document 09-033*
-

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*. 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.

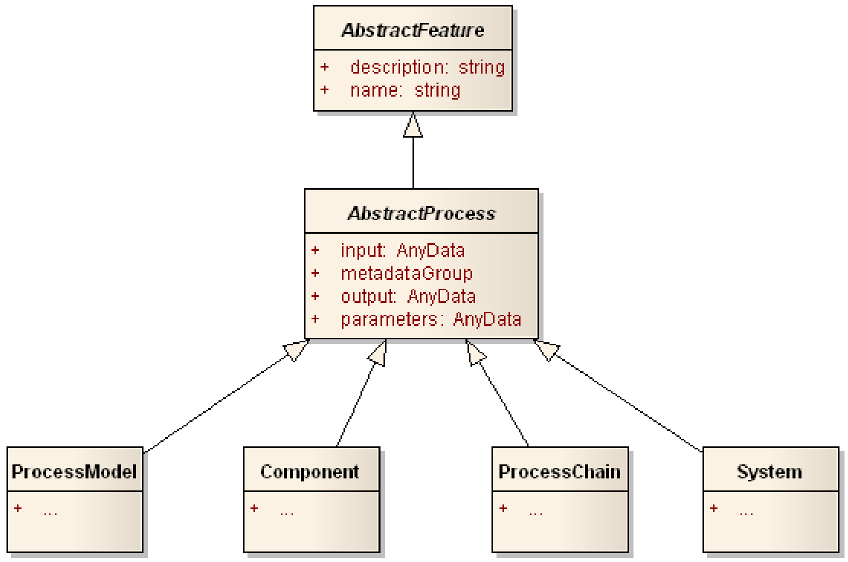

Figure 4-6. SensorML process types

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 .

4.2.6.3 Observations and Measurements (O&M)

References:

- *Observations and Measurements - Part 1 - Observation schema, OGC Document 07-022r1*
- *Observations and Measurements - Part 2 - Sampling Features, OGC Document 07-002r3*
-

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 spoken - 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 is 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.

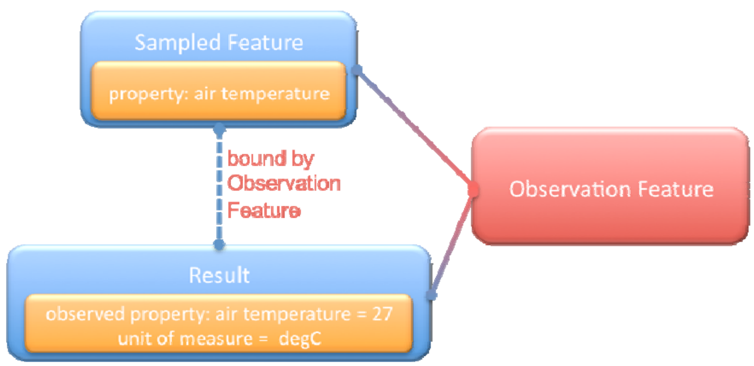

Figure 4-7. Binding of observation results to properties of the sampled feature

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.

4.2.6.4 UncertML

References:

- *Uncertainty Markup Language (UnCertML), OGC document 08-122r2*
- *OWS-6 SWE Information Model ER, OGC Document 09-031r1*

Uncertainty Markup Language (UnCertML) is an XML schema for describing uncertain information, which is capable of describing a range of uncertain quantities. Its descriptive capabilities range from summaries, such as simple statistics (e.g. the mean and variance of an observation), to more complex representations such as parametric distributions at each point of a regular grid, or even jointly over the entire grid.

UncertML supports the vision of the ISO/IEC guide to the expression of uncertainty in measurement (GUM). The GUM outlines the importance of quantifying uncertainty by stating that it is "obligatory that some quantitative indication of the quality of the result be given so that those who use it can assess its reliability" when discussing observations. The guide goes on to state that it is necessary to have a readily implemented and generally accepted procedure for characterizing the quality of a result of a measurement; however, it does not outline a mechanism for describing this information via an exchangeable medium.

The OWS-6 SWE Information Model ER discusses the use of additional markup languages with OGC SWE. OWS-6 experimented and documented the findings in the engineering report about the usage and integration of UncertML (has been integrated into different SWE encodings, namely SWE Common and Observations and Measurements), MathML and EML into the SWE environment with an emphasis on SensorML processes and processing.

4.2.6.5 GeoReferenceable Imagery

The term "image" has many meanings beyond those of geographic imagery. Geographic imagery is imagery whose data is associated with a location relative to the Earth. For example, to view geographic imagery, a presentation process is required. ISO 19101-2 defines Geographic Imagery Scene as imagery associated with a location relative to the Earth whose data consists of measurements or simulated measurements of the natural world produced relative to a specified vantage point and at a specified time. A geographic imagery scene may also be considered as an "observation coverage" which is more general and appropriate for describing the output of a remote sensor. Georeferenceable imagery is a type of geographic imagery scene.

Georeferenceable imagery is typically imagery coming from a remote sensor, which has not previously been georectified, resampled, or regridded. Georeferenceable imagery is expected to be accompanied with information sufficient to allow ground-to-image positioning of selected points, triangulation and georectification of the imagery with error management upon its receipt. In order to determine the precise location of the objects of interest with a given remotely sensed scene one must utilize models (typically referred to as "sensor models"), which provide a mapping of positions in the image to positions within the environment.

Within this text, the term *image* will generally be considered synonymous with a regularly gridded collection or coverage of observations coming from a remote sensor. While georeferenceable imagery typically exists within a regular grid, this grid is not regular within any geodetic coordinate system. That is, the imagery is usually obliquely oriented to geodetic systems (e.g. the latitude-longitude grid) and one cannot expect the spacing of pixels in the imagery to be equal distance; nor can one expect the size of the area covered by each pixel to be equal in area.

4.2.6.6 Motion Imagery

Reference: Motion Imagery Standards Profile (MISP) Version 5.3 3 September 2009

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-7, 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-7:

9720b - "High Definition Motion Imagery"

9720d - "Standard Definition Motion Imagery"

4.2.7 SFE 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 Sensor Observation Service (SOS)

Reference: OpenGIS Sensor Observation Service, OGC Document 06-009r6

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.

4.2.7.2 Sensor Planning Service (SPS)

References

- *OpenGIS Sensor Planning Service Implementation Specification, OGC Document 07-014r3*
- *OpenGIS Sensor Planning Service Application Profile for EO Sensors, OGC Document 07-018r2*

The Sensor Planning Service (SPS) is intended to provide a standard interface to collection assets (i.e., sensors, and other information gathering assets) and to the support systems that surround them. Not only must different kinds of assets with differing capabilities be supported, but also different kinds of request processing systems, which may or may not provide access to the different stages of planning, scheduling, tasking, collection, processing, archiving, and distribution of requests and the resulting observation data and information that is the result of the requests. The SPS is designed to be flexible enough to handle such a wide variety of configurations. SPS uses SWECommon to describe planning parameters that have to be set by users. SPS is often used together with WNS and SOS.

The SPS EO profile document specifies at a lower level the interfaces and parameters for requesting information describing the capabilities of a Sensor Planning Service dedicated to the EO Sensor domain, for determining the feasibility of an intended sensor planning request, for submitting such a request, for inquiring about the status of such a request, for updating or cancelling such a request, and for requesting information about further OGC Web services that provide access to the data collected by the requested task.

4.2.7.3 Web Processing Service (WPS)

References:

- *Web Processing Service Version 1.0, OGC Document 05-007r7*
- *Corrigendum for WPS 1.0, OGC Document 08-091r6*
- *Discussions, findings, and use of WPS in OWS-4, OGC Document 06-182r1*
- *OWS-5 Earth Observation WPS ER, OGC Document 08-058r1*
- *OWS-5 Considerations for the WCTS Extension of WPS, OGC Document 08-054r1*
- *OWS-6 WPS Grid Processing Profile Engineering Report, OGC Document 09-041r3*
- *The Specification Model — A Standard for Modular specifications, OGC Document OGC 08-131r3*

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 and OWS-6 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.

4.2.7.4 Geoprocessing Workflow

References:

- *OWS-6 Georeferenceable Imagery ER, OGC Document 09-034*
- *OWS-6 GeoProcessing Workflow Architecture ER, OGC Document 09-053r5*
- *OWS-5 GeoProcessing Workflow Architecture ER, OGC Document 07-138r1*

The OGC has focused on spatial related workflows for several years. Starting with OGC Abstract Specification Topic 12 – Services, (Also ISO19119:2001) the OpenGIS Consortium (OGC) and ISO TC211 have jointly developed an international standard for geospatial service architecture including the description of different workflow patterns. Beginning with OWS-2, every subsequent OWS testbed has explored Geoprocessing Workflows in detail.

Most recently the OWS-6 Geoprocessing Workflow Architecture ER presented several methods for Geoprocessing Workflows in a SOA environment. The OWS-6 ER begins with a definition of the term Geoprocessing Workflow and then goes over different methods of exposing GPW in a standardized way up to data patterns. Besides security aspects and in particular the delegation of authority aspects, the ER showed also how to model workflows in a language independent fashion and utilize asynchronous methods and as well as how to enrich workflows with semantic aspects.

Geoprocessing Workflows can be viewed as a combination of the two general concepts *Geoprocessing* and *Workflow*.

Geoprocessing is the processing of spatially related data. In classical desktop GIS and image processing applications, geoprocessing represents the core analysis functionality and thus is one of the key concepts. On the other side, distributed geospatial information systems are based on loosely coupled services organized in a SDI. According to the OGC AS Topic 12 there are four different types of Geoprocessing services: Spatial processing, Thematic processing, Temporal processing and Metadata processing.

Workflow is defined as an "automation of a business process, in whole or part, during which documents, information or tasks are passed from one participant to another for action, according to a set of procedural rules" (OGC AS Topic 12). Workflow can be realized as a web service chain in order to pass information from one workflow participant (web service) to another.

Geoprocessing Workflow brings both terms together and can be seen as an automation of a spatial process/model, in whole or part, during which information is passed from one distributed Geoprocessing Service to another according to a set of procedural rules using standardized interfaces.

4.2.7.5 Services for Notifications, Alerts and Events

4.2.7.5.1 Event Architecture

References:

- *OWS-6 Event Architecture ER, OGC Document 09-032*
- *OWS-6 Aeronautical Information Management Architecture ER, OGC Document 09-050r1*

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 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 (Figure 4-18). 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.

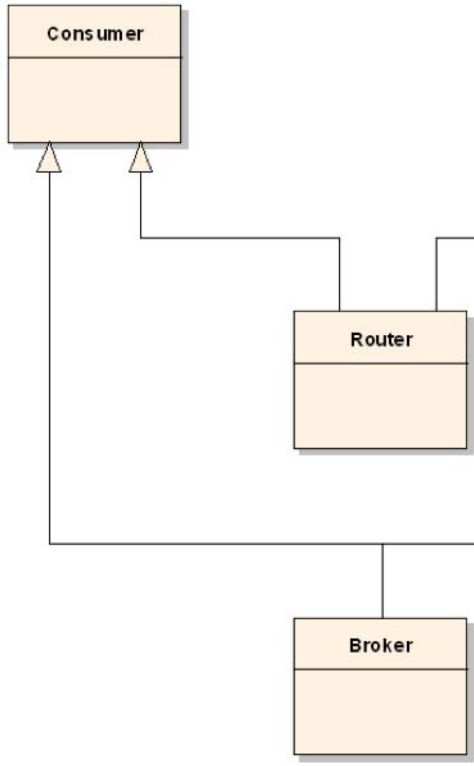

Figure 4-8. Overview of the Roles in the Event Architecture

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 4-9 creates updates through the WFS-T interface to update the database.

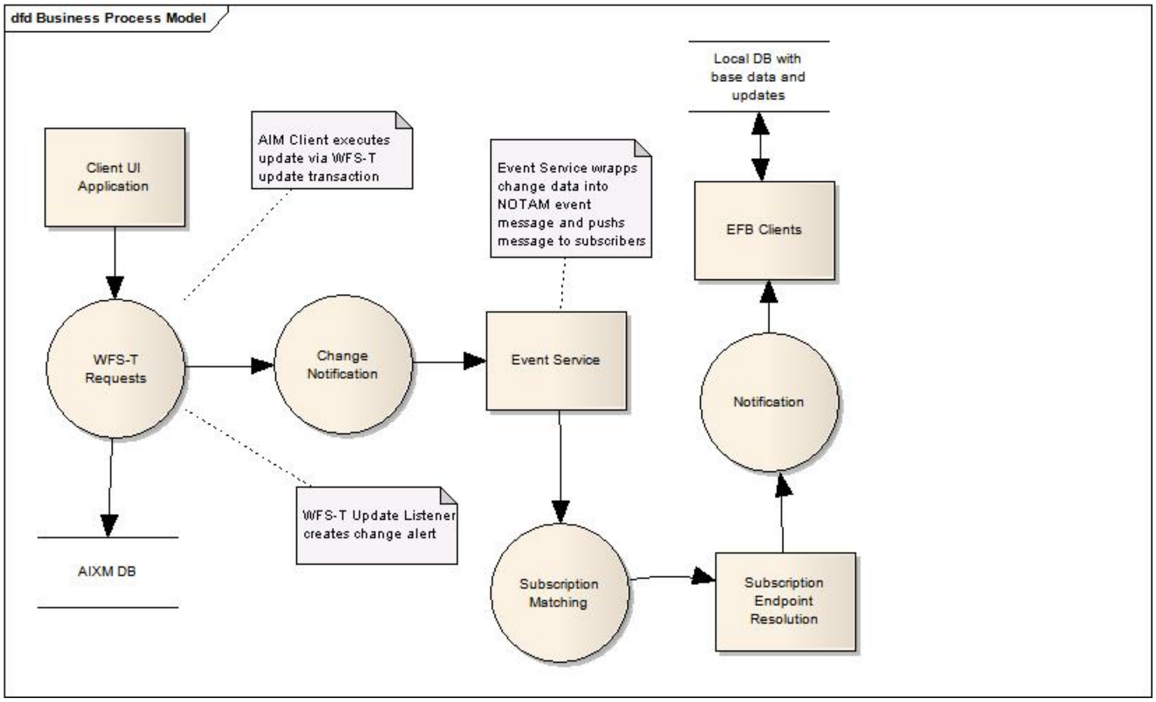

Figure 4-9. OWS-6 AIM Event Service

4.2.7.5.2 Sensor Alert Service (SAS)

Reference: Sensor Alert Service Discussion Paper, OGC Document 06-028r3

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.

4.2.7.5.3 Web Notification Service (WNS)

Reference: Web Notification Service Best Practice, OGC Document 06-095

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.

4.2.7.5.4 Notification from Fusion ER

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.

4.2.7.6 CCSI-Enabled Sensors in SWE

References:

- *OWS-6 CCSI-SWE ER, OGC Document 09-007*
- *OWS-6 SWE PulseNet™ ER, OGC Document, 09-073*
-

The OWS-6 CCSI-SWE ER outlines the concepts, best practices, and lessons learned gathered from integrating Common Chemical, Biological, Radiological, and Nuclear (CBRN) Sensor Interface (CCSI) standard-compliant sensors into an OGC Sensor Web Enablement (SWE)-based architecture. The document also specifies a web service interface for interacting with CCSI sensors and defines the basis for a profile that can be used to represent CCSI sensor definitions, data, and commands in SWE formats.

A number of Web services and corresponding clients have been developed to support the CCSI workflow. The following figure illustrates this workflow.

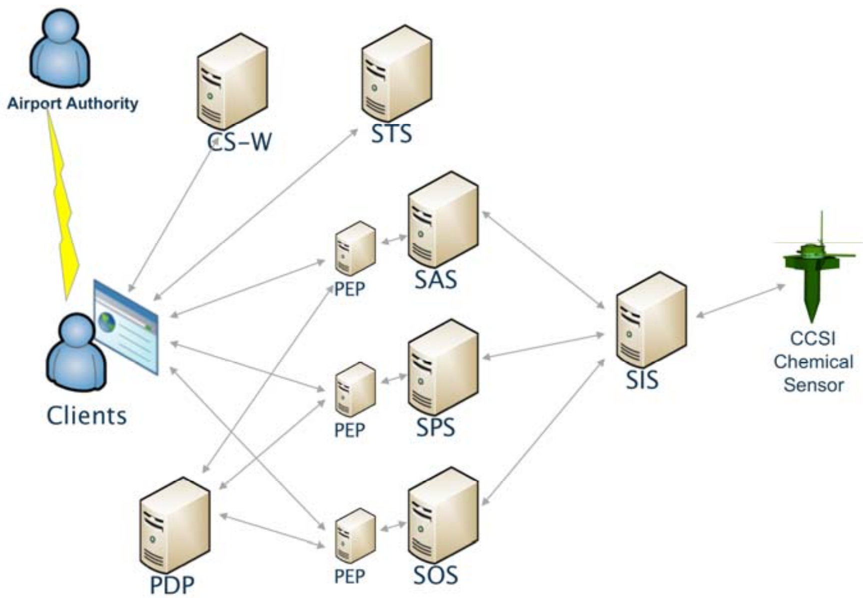

Figure 4-10. CCSI Workflow Overview

The Sensor Interface Service (SIS) provides serves as a middle-tier SOAP/WSDL-based web service (compliant with WS-I Basic Profile 1.1) that aggregates and connects CCSI sensors with interested consumers. The SIS provides a web service interface that acts as an intermediary between a SWE client and one or more CCSI-enabled sensors.

The OWS-6 SWE PulseNet ER summarizes implementation of the CCSI interfaces into an OGC SWE-based architecture.

4.2.7.7 SWE Computational Use Cases

4.2.7.7.1 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.

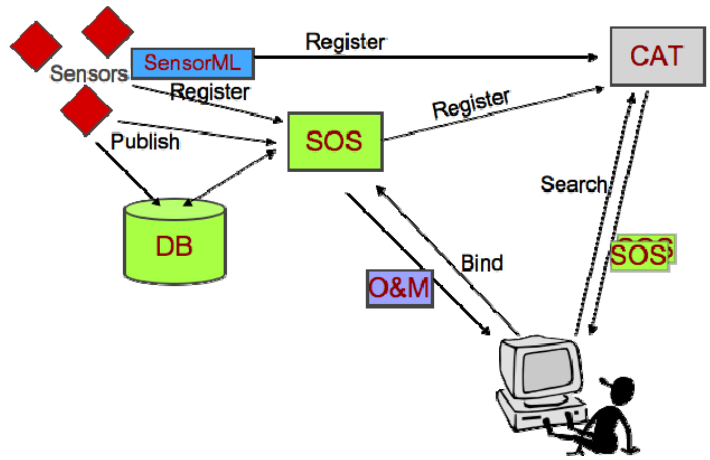

Figure 4-11. SWE Discovery and Access Use Case with SOS

4.2.7.7.2 SWE Tasking and Access Use Case with SPS

The situation gets a bit more complex in the following. Let's assume that the catalog didn't provide any SOS instances that fulfill the requirements set by the user. In this case, the user may search for SPSs that could task sensors to perform appropriate actions in order to produce the observation data our user is looking for. The catalog provides the link to the SPS instance and the user assigns the task. The SPS forwards the command to the sensor. The communication between the SPS and the sensor is opaque for the user. If we imagine a satellite that has to reorient its infrared cameras and has to reach its target position in space, the tasking might take a while. Once observing the requested scene, the sensor dumps its data into a database that is linked to a SOS. The SPS informs the user about data availability using a Web Notification Service. This has the advantage that the SPS can respond to the tasking request right away and has a mechanism to reach the user at a later stage, e.g. if the data is available or if the tasking is delayed or cancelled. The notification message contains all necessary information to access the data from a SOS.

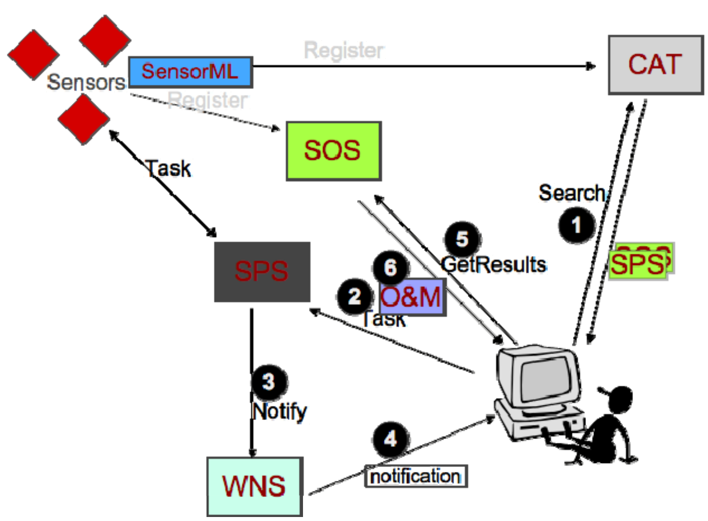

Figure 4-12. SPS Tasking and SOS Access Use Case

4.2.7.7.3 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. illustrates this use case.

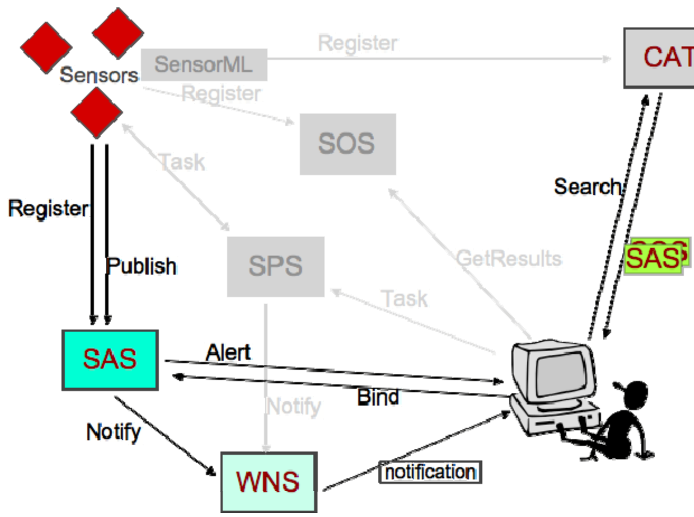

Figure 4-13. Notification with SAS and WNS Use Case

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.

4.2.7.8 Secure Sensor Web

References:

- *OWS-6 Secure Sensor Web ER, OGC Document 08-176r1*
- *OWS-6 Security ER, OGC Document 09-035*
-

The OWS-6 Secure Sensor Web ER analyzes security aspects for SWE applications. The report provides a detailed analysis of potential vulnerabilities and threats typical for SWE services. The ER identifies a set of requirements for secure sensor webs based on the Trusted Computer System Evaluation Criteria (TCSEC), A Security Architecture for Net-Centric Enterprise Services (NCES), the Internet Threat Model, as defined in IETF RFC 3552, and ISO 10181, "Security Frameworks for Open System"

The ER analyzes the vulnerabilities and potential attacks that exist in the SWE baseline and in the different ways of implementing the identified requirements. Because this analysis is so exhausting that the scope is limited to a given use case and its scenarios.
The ER focuses on the implementation of message level security to Web Services, as they exchange XML structures messages. The flexibility of message level security can be leveraged

to individually implement a Secure Sensor Web. The foundation of Message-Level Security is given by a handful of standards:

- XML by W3C
- SOAP by the W3C
- WS-Security by OASIS
- XML Digital Signature by W3C
- XML Encryption by W3C
- SAML by OASIS

The most important standard is WS-Security from OASIS. It basically provides the means to secure a SOAP message towards integrity and confidentiality.

The OWS-6 Security ER was also developed in OWS-6 but not specifically for SWE. It addresses security aspects for all OGC Web Services. As the Sensor Web includes services that supersede the services from the GPW thread, the Secure Sensor Web ER is a complement to that report.

4.2.8 SFE Engineering Viewpoint

4.2.8.1 Motion Image Components Data Flows

Access and gelocation of full motion video was an emphasis of the OGC Pilot for Empire Challenge in 2008. The as-built engineering components deployed in EC'08 for motion video is shown in Figure 4-14. 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.

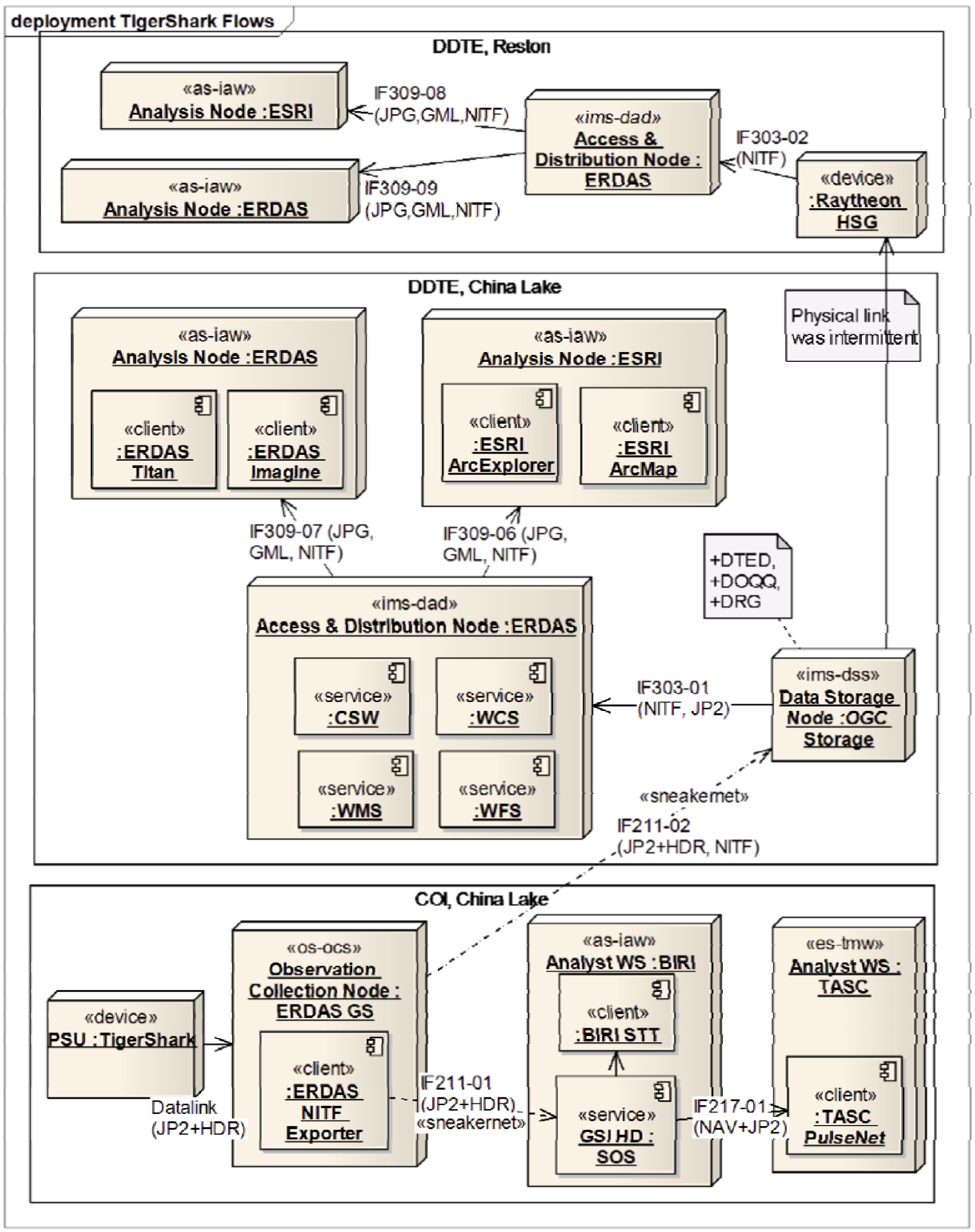

Figure 4-14. EC '08 Motion Imagery Engineering Components

4.2.8.2 Georeferenceable Imagery Deployment Architecture

References:

- *OWS-6 Georeferenceable Imagery ER, OGC Document 09-034*
- *OWS-6 GeoProcessing Workflow Architecture ER, OGC Document 09-053r5*
-

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.

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.

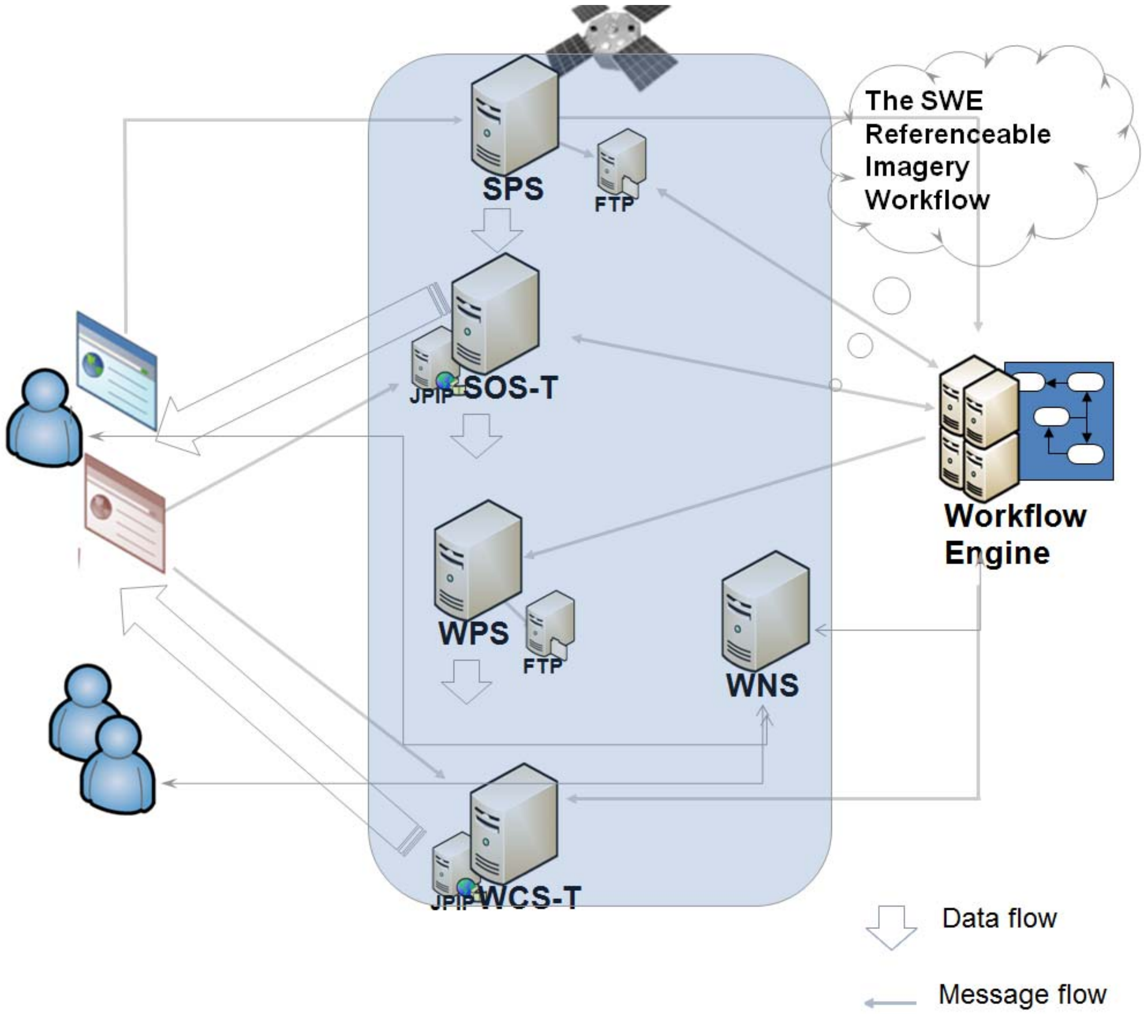

Figure 4-15. Data and message flow in georeferenceable image workflow

4.2.8.3 CCSI-enable Sensors in SWE Components

Following the general SWE use case, a user with SWE client software connects to a CS/W instance and discovers available SWE services that provide CBRN sensors and data of interest. The user then employs his or her SWE client to connect to the previously discovered SWE services and retrieves sensor information and data, submits sensor tasking commands, and subscribes to and receives sensor alerts as desired. Behind the scenes, each of these SWE services discovers and interacts with the CBRN sensors through an intermediary web service called the Sensor Interface Service (SIS).

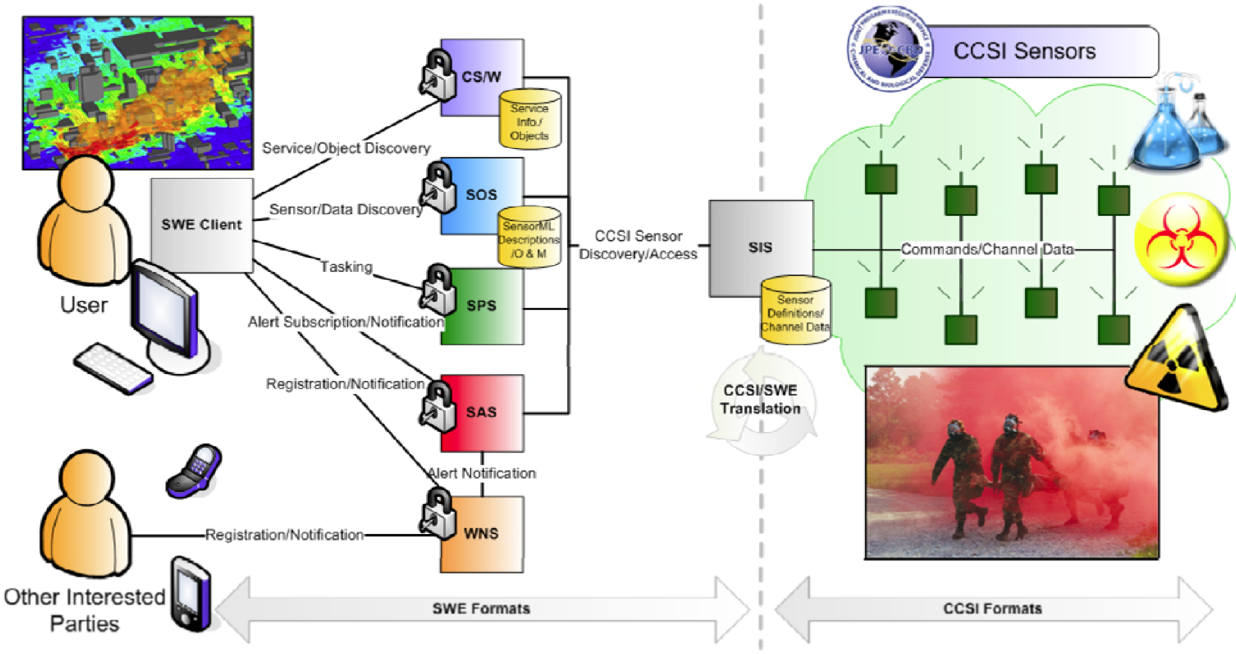

Figure 4-16. Notional CCSI – SWE Architecture

4.3 Feature / Decision Fusion (FDF) Thread

4.3.1 FDF Background

Reference: Fusion Standards Study Engineering Report, OGC Document 09-138, draft 02 October 2009. Contact the OGC Technology Desk (techdesk@opengeospatial.org) for access.

In past OWS test beds, the work to be covered in this thread was divided between two separate threads: Geo-Processing Workflow (GPW) and Decision Support Services (DSS). The current FDF thread is designed with a focus on both information fusion and decision fusion, as described in Sections 2.1 and 4.1, and with the intent of more tightly coupling the development of the Integrated Client application with the underlying workflow processes, than was done in previous test beds.

4.3.1.1 Object/Feature Fusion

Object/Feature Fusion is the processing of multiple sources of observations and features into more meaningful features, information and knowledge, using techniques for identifying, aggregating, relating, parsing, and organizing disparate forms of data. This may involve geospatial feature processing techniques such as generalization, conflation, feature extraction, and change detection. The goal of Object/Feature Fusion is to produce information resources that are more powerful, flexible, and accurate than the original sources.

Critical to Object/Feature Fusion is understanding and generating metadata that record the provenance (i.e., lineage, pedigree, chain of custody and processing) of the sources and the nature of feature fusion processes that have been applied to derive “value-added” information from them.

The ”end game” is to improve a user’s understanding of an operational situation, and assess potential threats and impacts by integrating multiple data formats, data models, and tools to identify, classify, associate, and aggregate entities of interest (i.e., targets, features, tracks, objects, activities). The ability to automate processing, and scale up storage, networks, and computing capabilities to suit growing data volumes and analytical complexities becomes increasingly critical.

The terminology for geographic information standards differs from terminology used in the field of image understanding. A *feature* in the ISO 19100 series of standards is an *object* in image understanding terminology. A *geometric object* identified in an image in the ISO 19100 series is a *feature* in image understanding terminology. Hence, both terms may be used somewhat interchangeably, but the context of usage should make clear in which domain we are writing.

4.3.1.2 Decision Fusion

From the Fusion Standards Study ER, 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 conducted using social networking services and collaboration tools that are location-enabled.

The objectives for decision fusion include:

- Discovery of data (static and dynamic) resources that meet a user's immediate requirements and to make those resources part of a fusion process under the control of the decision maker or analyst.
- Retrieval of real-time or time-series data in standard encodings that provide the ability to fuse the data into useable information based upon the users uncertainty of the measurement and parameters needed to process the data.
- Determination of the quality and validity of the data and fusion products produced from the data.
- Ability to fuse derived data and information with processes, policies, and constraint information as set by the data/information owners (i.e., Concept of Operations) and decision services processing nodes.
- Ability to present the derived information in a spatial client application (e.g., SLD, SE, W3D) including portrayal of maps and 3D visualization.
- Ability to collaborate with other decision makers and analysts using social networking services and collaboration tools that are location enabled. Documents may capture an analysis result and allow for distribution to others for viewing the same context.

While Sensor Fusion and Feature Fusion provide the "right data", Decision Fusion provides that information in the "right time, the right place, and for the right purpose". Decision Fusion pulls together Sensor Fusion and Feature Fusion results, and combines these with additional data inputs to provide a result on which decisions or actions can be executed.

A key part of decision support is the ability to overlay, integrate, and visualize multiple disparate sources of information, as shown in the figure below. Many more types of data, as well as geoprocessing workflows, will be combined during OWS-7.

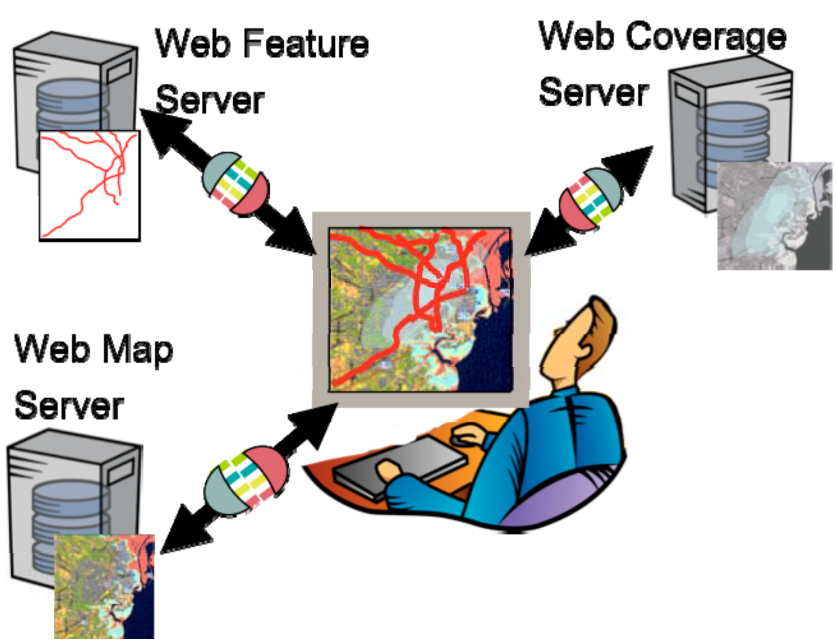

Figure 4-17. Example Decision Support Workstation

4.3.2 FDF Scope

We cannot fully address all the recommendations from the Fusion Standards Study within a single OGC test bed initiative, so will pursue a prioritized subset. It is also our goal in OWS-7 to build on OWS-6 GPW and DSS work, in particular to advance the state of information cataloguing, Web Processing Services (WPS) profiles, and capabilities of the Integrated Client. The following task areas have been identified for the Feature / Decision Fusion Thread:

- Schema Automation. Transformation from UML to profiles of GML and KML, including generation of constraints.
- Data Discovery and Organization. Use of thematic categories in multi-source data discovery, including augmented metadata for quality of source, fitness for use, and uncertainty of the data values, propagated through usage and workflow.
- Feature and Statistical Analysis (FSA). WPS profiles for feature fusion, including statistical analysis, vector and topological processing. WFS, WMS and WMTS will be used to support statistical mapping.
- Data and Analysis Sharing. The use of OWS Context for collecting links to web services and analysis results.
- Geosynchronization. Web services and client components to support synchronization of geospatial data and updates across a hierarchical Spatial Data Infrastructure (SDI).
- Integrated Client. A field-ready client application to support and display sensor information, cataloguing metadata, notification alerts, feature and statistical analysis, geosynchronization, and OWS Context. This client will include an embedded WFS server for geosynchronization support.

These will be discussed in more detail in the following sections.

4.3.3 FDF Requirements

4.3.3.1 Schema Automation

References:

- *NAS 1.8 http://www.gwg.nga.mil/documents/asfe/NAS_v1.8.pdf*
- *NAS 2.0 [GFI]*
- *DGIWG Profiles of ISO 19107 and GML realization draft standard [GFI]*
- *2007 DoD Discovery Metadata Specification (DDMS) [GFI]*

OWS-7 will further the development and interoperability of OGC Geography Markup Language version 3.2.1 application schemas. Part of this effort will be to create a GML encoding of the U.S. *National System for Geospatial Intelligence (NSG) Application Schema (NAS).* The draft NAS v2.0 [Government-Furnished Information, GFI] will be compared with the DGIWG_Profiles_of_ISO_19107_and_GML_realization draft standard [GFI] to determine opportunities for harmonization and necessary revisions to (or extensions to) the NAS in order to improve interoperability with other DGIWG-associated data provider/consumers. Additionally, OCL constraints will be encoded in the NAS UML, and profiles of the NAS, model for generating corresponding GML XSD (XML Schema) and SCH (Schematron) documents.

OWS-7 will explore the capabilities of OGC's KML 2.2 as a format for exchange and visualization of NSG data. The intent of this effort is to leverage the KML <ExtendedData> tag to assert well-formed typed user data based on the <Schema> and <SchemaData> elements. It is to be considered whether leveraging the GML-SF standard may be a suitable basis for defining external schemas (and their data types) so as to increase the level of interoperability between KML-based data exchanges and those based on GML. An automated methodology for generating the necessary KML-associated schemas based on the standardized NAS encoding will be developed by leveraging existing UML-to-GML Application Schema (UGAS) tool(s).

GML application schemas and KML schemas shall include associated metadata for discovery of these application schemas through an OGC catalog based on guidance provided by the July 2007 DoD Discovery Metadata Specification (DDMS) (GFI). KML capabilities for the capture of metadata and encoding of the NAS will be analyzed. All analysis and recommendations shall be incorporated into the OWS-7 Schema Automation Engineering Report.

The list below describes modifications required to the UML to GML application schema software tool ShapeChange to support OWS-7 requirements.

- Validate and document within the Schema Automation Engineering Report the capability for ShapeChange to generate GML application schemas based on the requirements of the DGIWG_Profiles_of_ISO_19107_and_GML _realization draft standard.
- Generate NAS based KML application schemas.
- Enhance the ShapeChange tool as required to make use of a variety of "dictionaries" such as Unit of Measure dictionary.
- Enhance ShapeChange to generate a KML 2.2 output from base UML models.
- Enhance ShapeChange to make full use of Object Constraint Language (OCL) and / or Schematron constraints incorporated as part of the NAS.

4.3.3.2 Feature and Statistical Analysis

A major thrust in the FDF Thread is to provide support for thematic, statistical, exploratory, spatial/topological and other forms of analysis with open access (public, non-standard) and multi-media data of a socio-cultural nature. This is of primary importance to anticipate, prepare for, and mitigate situations requiring urgent and emergency response. For convenience in this RFQ, we will refer to all these forms of analysis simply as *Feature and Statistical Analysis (FSA)*, which we define as a *multidisciplinary scientific approach to describe and predict spatial and temporal patterns of human behavior by analyzing the attributes, actions, reactions and interactions of groups or individuals in the context of their environment*. FSA incorporates elements of Human Geography in a spatial, temporal context. FSA includes aspects of Socio-Cultural Dynamics (SCD), which is defined as information about the social, cultural and behavioral factors characterizing the relationships and activities of the population of a specific region. FSA also includes geospatial vector and topology processing operations.

Research indicates the following "themes" are common across domains of information to be considered for FSA:

Table 4-3. Socio-Cultural Themes for FSA

Theme	Description / Examples
Demographics	Population characteristics and distribution
Religion	Groups, subgroups, facilities
Language	Groups, subgroups, spatial distribution
Ethnicity	Tribes, clans, affiliations
Economics	Businesses, livelihoods, trade routes, distribution networks
Education	Schools, literacy
Land Use	Agriculture, herding, commercial/industrial
Medical/Health Environment	Hospitals, doctors, disease, infant mortality
Political Affiliation (ideological)	Parties/groups, zones of influence, affiliations
Communication/Media Preferences	TV/radio coverage, newspapers
Significant Events (history)	Conflicts, crisis, political changes

The FDF Thread will analyze existing standards (OGC, OASIS, etc) that are applicable to advanced methodologies for discovery, retrieval and utilization of socio-cultural data and analysis within a GEOINT context. This analysis will define an integrated capability comprising infrastructure, organization, methods and tools. The goal is to enable analysts to effectively discover, validate, consolidate, visualize, characterize and model socio-cultural data in the context of the GEOINT analytic framework.

A Web Processing Service (WPS) will be implemented, with profiles corresponding to feature fusion and decision fusion operations called for by the analytical approaches selected. In addition to FSA processing, the WPS shall support basic polygon processing and topology operations, with consideration for approaches such as the Egenhofer relations, Java Topology Suite, and GRASS (e.g. polygon overlay). For more detail, see Section 4.3.7.3.

OGC WFS, WMS and WMTS capabilities will be implemented for accessing open (public) data sources and generating map displays based on spatial and statistical information found on these sites. Information will be combined to generate data in the context of the GEOINT analytic framework for FSA. For example, the combination of demographics, economy, medical facilities and H1N1 virus statistics can yield more information about the potential spread of the infection than simply noting the locations and numbers of the infected.

The results, requirements and capabilities of OGC WFS, WMS and WMTS to support statistical mapping will be documented in a Feature and Statistical Analysis Engineering Report.

4.3.3.3 Data Discovery and Organization

References:

- *ISO 19113 – Geographic Information – Quality Principles*
- *ISO 19114 – Geographic Information – Quality Procedures*
- *ISO 19115 – Geographic Information – Metadata*

A key part of the support for feature and statistical analysis will be a catalogue or registry providing improved capability to discover, organize and access relevant data sources. Analysis will be made of OGC standards-based catalogues and catalogue profiles capable of organizing and discovering a wide variety of types of data (web sites, books, pictures/images, etc.) and web services. Categorization shall be based on the socio-cultural themes listed in Table 4-3.

A Directory, Catalogue, Registry or alternative for publishing and querying Standard and Non-Standard content, including "open source" or "open access" will be implemented. This may be RESTful; examples include OGC Catalog Service for the Web (CSW), Resource Description Framework (RDF) data store, or other form as most appropriate, with the ability to identify and query for data sources based on geographic area (either coordinates or geographic name), temporal relevance, and quality of data source information (fitness for use).

The results of the analysis of OGC catalogue, catalogue profiles, and alternatives to satisfy the "Authoritative Data Source Directory " (or ADSD for short) concept will be documented in the OWS-7 Authoritative Data Source Directory Engineering Report, including the capture of metadata for temporal relevance and quality of information. This Engineering Report shall include lessons learned through the development and implementation of this service as well as efforts related to the client implementation. Additionally, Change Requests will be written against existing OGC standards based on the results of this effort.

An interactive interface client will be provided for updating catalogue information (descriptions) including associated metadata (e.g. quality information).

4.3.3.4 Data and Analysis Sharing

References:

- *OGC Web Services Context Interoperability Experiment Final Report (OGC Document 05-062)*
- *OGC Geospatial Fusion Services Testbed [working documents provided on request from techdesk@opengeospatial.org]*
- *OGC Web Services Context Schema v0.3.1 (http://www.ogcnetwork.net/schemas/owc/0.3.1/)*

OWS-7 will investigate the capabilities for sharing data analysis between multiple users. Specifically, sponsors are interested in an evaluation and comparison of the capabilities developed within the OGC Web Services Context Interoperability Experiment Final Report (OGC 05-062) and the OGC Geospatial Fusion Services Testbed (2000-2001) concept for a Location Organizer Folder, an XML document created to share the results of a work session with any one else. These approaches will be studied and prototyped to determine the viability of merging these concepts for efficient sharing of multi-media information (standard and non-standard formats), supporting at least the following: WMS, WFS, GML, KML (these 4 already in v0.3.1), WPS, WCS, SOS, imagery annotations (points, lines, polygons, rectangles, and text -- georeferenced and in paper-space), Geo-processing models (GPMs), email, images, geo-images, documents (PDF, Word, PPT, etc), web pages (HTML), and arbitrary XML.

OWS Context shall be extended to use SLD for local as well as remote rendering, ie, without needing a WMS call.

The results of this analysis shall be documented within an Information Sharing Engineering Report, to describe the OWS Context with Multimedia information model and schemas, modularized per recent OGC guidelines (OGC Document 08-131r3).

4.3.3.5 Geosynchronization

References:

- *Loosely Coupled Synchronization of Geographic Databases in the Canadian Geospatial Data Infrastructure Pilot, OGC Document 08-001*
- *OGC CGDI WFS and GML Best Practices ER, OGC Document 08-002*
- *Geo-Synchronization Service, OGC Document 08-003*

A common issue in emergency response, as well as in other contexts, is bidirectional communication and data sharing up and down a chain of command. One of the difficulties is that database schemas and content at the local or field level are generally much more detailed than at regional or national levels. It is difficult to synchronize data with dissimilar schemas. However, there is strong interest at the regional and national levels to aggregate and integrate data sources originating at the local or field level, because the local data tends to be much more accurate, and is very costly to collect at that resolution for regional or national purposes.

Another problem occurs because, at the local or field level, there is much greater variation in data formats used, and level of metadata collected. It has been found to be unrealistic to require or expect local/field level users to only use standard formats and interfaces. In contrast, at regional and national levels, standard data formats are much more commonly used, if not required and enforced. So, a further difficulty in data synchronization is to accept and convert non-standard source material into standard encodings and interfaces.

In the OGC Canadian Geospatial Data Infrastructure (CGDI) Pilot Project conducted in 2008, these issues were addressed by embedding a WFS and Atom Pub notification server within the synchronization client application at all levels in the chain of command and communications. This way, upon storing data updates, subscribers could be notified from any user's workstation up or down the chain of command. Another workstation in the chain could then make a WFS request for the updated content, and receive just those data fields appropriate for that user's respective level. This is a flexible and versatile approach, requiring essentially incremental maintenance due to changes once the system is in place.

The following tasks shall be performed in support of this requirement. See the primary demonstration scenario in Section 4.3.5.2.

1. Develop a detailed technical architecture, describing the interaction and operation of the service components that will satisfy the overall objectives for this project.
2. Demonstrate implementations of Authoritative Data Source Directory, OWS Context with Multimedia, Geosynchronization services and clients, according to the requirements stated above and the detailed technical architecture.
3. Demonstrate implementations of geosynchronization service and client for desktop and mobile (digital pen or touchscreen) platforms, based on OGC WFS or similar capability. (All client applications for information to be synchronized will include an embedded server.)

   The desktop client shall be an Integrated Field Client with support for the Authoritative Data Source Directory, OWS Context with Multimedia, sketching and text annotation for maps and/or imagery, WPS Profile(s) for FSA and Vector/Topology Operations (see Section 4.3.3.6), and event notifications.
4. Develop the Geosynchronization Engineering Report to include the following information, modularized according to recent OGC guidance [OGC Document 08-033r3]:
   - A refined use case including alternative scenarios as appropriate.
   - Detailed technical architecture, implementation results, and lessons learned.
   - Technical guidance for procurement.
5. Contribute to recommendations for standards development in OGC Technical Committee:
   - Authoritative Data Source Directory for thematic datasets, categorized by quality and fitness for use, see Section 4.3.3.3.
   - OWS Context with Multimedia information model and schemas, see Section 4.3.3.4.
   - Web Processing Service Profile(s) for FSA and Vector/Topology Operations, see Section 4.3.3.2.
   - Notifications system to subscribe and publish data update events. See also Section 4.2.3.2.
   - Geosynchronization of data across the chain of command.

4.3.3.6 Integrated Client

Reference:

- *OWS Integrated Client (GeoDSS Client), OGC Document 05-116*
- *Integrated Client for Multiple OGC-compliant Services, OGC Document 03-021*

The FDF Integrated Client is an essential component of the frameworks for both Feature Fusion and Decision Fusion, and plays a prominent role in the final demonstrations of many OWS-7 requirements. At the core of the integrated client concept is the requirement to provide a unified environment that allows a user to simultaneously visualize, analyze, and/or edit data from multiple sources. The development of this client will build on the results of prior OWS Testbed Integrated Clients. The Integrated Client is defined as a software application that provides common functionality for the discovery, retrieval, and handling of data from WMS, Component WMS, WMTS, WFS, WFS-T, WCS, SPS, SOS, video, and notifications. Search may be implemented via support for the CS/W ebRIM profile, and state handled by support for WMS Context and/or OWS Context documents. The Integrated Client will extend the OWS-6 Integrated Client capabilities to include the services developed and enhanced through OWS-7.

For OWS-7 this particularly includes the ability for the client to:

- Support WPS profiles for FSA, and Vector/Topology Processing, see Section 4.3.3.2.
- Support WFS, WMS and WMTS for access and mapping of feature data and multi-media content.
- Support Authoritative Data Source Directory (Section 4.3.3.3).
- Create, use, and manage OWS Context documents, see Section 4.3.3.4.
- Support geosynchronization and related notifications, see Section 4.3.3.5.
- Support multiple languages.

In cross-thread coordination for event notifications, the FDF thread shall coordinate and document recommendations, solutions and open issues with the SFE team responsible for the event architecture. It is expected that FDF Thread participants responsible for the FDF Integrated Client will coordinate and participate directly with the SFE Thread team from the beginning, to best understand data, processing and user requirements.

4.3.4 FDF Deliverables

The OWS-7 FDF thread requires two types of deliverables:

- **Engineering Reports and Documents**: 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-7" in the title, to facilitate later literature searches.

- **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.

4.3.4.1 FDF Engineering Reports (ERs) and Documents

The following Engineering Reports (ERs) and Schemas will be developed in the FDF thread and submitted to the OGC Specification Program at the completion of the OWS-7 Testbed.

Table 4-4. FDF Engineering Reports and Schemas Required

1)	OWS-7 Schema Automation ER: Use of ShapeChange to generate DGIWG-profile GML and KML application schemas from NAS UML; schema discovery metadata. Schemas for GML and KML shall also be delivered, consistent with OGC's policy for specification modularity (OGC Document 08-131r3).
2)	OWS-7 Feature and Statistical Analysis ER: Analyze existing standards (OGC, OASIS, etc) for advanced methodologies for discovery, retrieval & utilization of socio-cultural data and analysis; define integrated capability comprising infrastructure, organization, methods and tools, to enable analysts to effectively discover, validate, consolidate, visualize, characterize and model socio-cultural data & dynamics in GEOINT context. Document WPS Profile for FAS. Document use of WFS, WMS, WMTS for statistical mapping, and support for vector and topology operations.
3)	OWS-7 Authoritative Data Source Directory ER, for standard and non-standard sources from foundation socio-cultural themes, and metadata for fitness for use, quality, and uncertainty measures (coordinated with Sensor Metadata ER). ER includes description of interactive client application to update directory information and metadata.
4)	OWS-7 Authoritative Data Source Directory Schema (To be included in the OWS-7 Authoritative Data Source Directory ER, consistent with OGC's policy for specification modularity (OGC Document 08-131r3).
5)	OWS-7 OGC Catalogue Service Change Request, based on lessons learned from Authoritative Data Source Directory development and use.
6)	OWS-7 Information Sharing ER. Evaluation of approaches for improving and merging OWS Context and Location Organizer Folder (LOF) concepts into support for OWS Context with Multimedia.
7)	OWS Context + Multimedia Schema. (To be included in the OWS-7 Information Sharing ER, consistent with OGC's policy for specification modularity (OGC Document 08-131r3).
8)	OWS Context + Multimedia Change Request.
9)	OWS-7 Geosynchronization ER. Description of technical architecture, and use of WFS, transaction logs, and notifications to enable synchronization of data throughout a chain of command, supporting varying levels of detail and fitness for use.

4.3.4.2 Software Components: Services, Clients, and Tools

Implementations of the following services, tools and data instances will be developed in this OWS-7 thread, tested in Technology Integration Experiments (TIEs) and invoked for cross-thread scenarios for OWS-7 demonstration events:

Table 4-5. FDF Services, Clients and Tools Required

1) ShapeChange UGAS enhancements: Use of dictionaries; use of OCL / Schematron constraints for NAS profiles	Tool
2) ShapeChange extension to support KML 2.2 output	Tool
3) Automation of ISO 19139 compliant metadata from NAS	Tool
4) Authoritative Data Source Directory service, enabling discovery & retrieval of thematic, statistical, multimedia, standard and non-standard data within Area of Interest and temporal constraints	Service
5) WPS for Feature and Statistical Analysis, including vector and topology operations	Service
6) Services for Feature and Statistical Analysis: WFS, WMS, WMTS	Service
7) Geosynchronization notification service	Service
8) "Embedded" Geosynchronization service/client	Service/Client
9) "Embedded" WFS, for geosynchronization with mobile devices	Service
10) Integrated Client: supporting ADSD, OWS Context + Multimedia, Geosynchronization, notification alerts, Feature & Statistical Analysis, WFS/WMS/WMTS Statistical mapping	Client

4.3.5 FDF Enterprise Viewpoint

4.3.5.1 Community and Objectives

The context for feature and decision fusion can be one of critical urgency. Lives, resources, diplomatic efforts, and civil order may depend on the outcomes of these fusion processes. Complicating the analytical processing is the need for coherent and consistent communications and data throughout a hierarchical chain of command. This is true in both defense and civil applications. The regional and national organizations involved could be emergency response agencies, centers for disease control, theater and national defense commands, and so on. See the initial discussion of Geosynchronization requirements in Section 4.3.3.5 for the enterprise-level motivation driving the FDF thread in OWS-7.

The demonstration scenario to be addressed involves an H1N1 ("Swine flu") outbreak in an urban setting. Medical field staff and their software tools will interact with city-level, regional (state-level), and national level organizations that will consume the field and intermediate stages of data and data preparation.

4.3.5.2 FDF Enterprise Use Case

Use Case Identifier: FDF #1	**Use Case Name:** H1N1 Virus Outbreak Response	
Use Case Domain: OWS-7 FDF		**Status:** Draft 2009-10-24
Use Case Description: The use case describes the scenario for managing data collection, processing, and synchronization for an outbreak of the H1N1 virus in an urban area. Field		

<table>
<tr><td colspan="2">medical staff collect data, which is passed up the chain of command. Command level staff process the data, send notifications of actions needed, and pass data back down the chain of command. Routing and logistics are determined for mobilizing the response team and equipment.</td></tr>
<tr><td>Actors (Initiators):
• Field medical staff
• City-level information coordination center
• State-level information coordination center
• National disease information coordination center</td><td>Actors (Receivers):
Same as initiators</td></tr>
<tr><td>Pre-Conditions:
• An outbreak of H1N1 virus has occurred in a city.
• Chain of command for communications and control has been established, and a state of alert has been activated, based on the reports of the outbreak.</td><td>Post-Conditions:
Virus outbreak source and vectors are identified, verified, and contained.</td></tr>
<tr><td colspan="2">System Components:
1) Touchscreen or pen input device, capable of uploading its data to a local desktop
2) Field desktop client application, with integrated WFS server, docking station for input device, and capabilities of FDF Integrated Client.
3) Command level desktop client, with integrated WFS server, and capabilities of FDF Integrated Client.
4) WPS and models supporting FSA and Vector/Topology Processing
5) Authoritative Data Source Directory server</td></tr>
<tr><td colspan="2">Basic Course of Action:
1) A member of the field medical staff is dispatched to a given location for data collection.
2) Upon arrival at the scene, the medical staff collects the requested data, using a mobile touchscreen or digital pen device.
3) The medical staff returns to the office, docks the data collection device, and uploads the information collected onto a local desktop computer, where it is added to the OWS Context document.
4) Upon completion of the upload, notifications are sent to subscribed recipients, with a link to the transaction log of the changes made.
5) At a higher level of command responsibility, the city-level coordination center, the transaction log is received and processed for information considered relevant to that</td></tr>
</table>

command, as determined by "fitness for use" tags applied to the referred documents.

6) The city level coordination center accepts the new data, and considers it important enough to pass up the chain of command to the state and national level. These centers receive the notification, access and process the transaction log, and queue up the necessary contacts and other resources.
7) As a result of geoprocessing the field data, along with other available data sources, areas at most risk are identified, and a plan for moving hospital staff and extra supplies from more remote hospitals to those closest to the outbreak is worked out. Subsequent geoprocessing determines the best routes for movement of the staff and equipment.
8) The plan is communicated back down the line using a subsequent synchronization transaction log, which is received and processed at the state, city, and field staff levels. Additional two-way updates are reported throughout the communications chain as the plan is carried out.
9) Information is provided that shows the outbreak has been contained and is dying out. Success!

Success Guarantee

The use case provides the opportunity to geosynchronize information up and down the chain of command, and to access and process the data using standard interfaces. By keeping local copies of all update transactions and related data at each level in the hierarchy, the system is not dependent on the network condition any more than necessary for notifications and access requests. Each geosynchronization service is capable of operating in "standalone" mode if needed.

4.3.6 FDF 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 OWS-7. This section will consider these according to the areas discussed in the Enterprise Viewpoint.

4.3.6.1 Fusion Information Management and Persistence of State

References:

- *OpenGIS® Web Map Context Implementation Specification, OGC Document 05-005*
- *Web Map Context Documents – Corrigendum 1, OGC Document 08-050*
- *OGC Web Services Context Documents (OWS Context) IE Final Report, OGC Document 05-062*
- *OWS Context working schema at http://www.ogcnetwork.net/schemas/owc/0.3.1/*
- *OWS-5 KML Engineering Report, OGC Document 07-124r2*
- *OWS Integrated Client GeoDSS Client, OGC Document 05-116*
- *Open Annotation Collaboration http://www.openannotation.org/index.html*

- *Fotonotes Image Annotation Standard and Scripts v0.2* *http://www.fotonotes.net/*
- *SpatialML* *https://sourceforge.net/projects/spatialml/*

4.3.6.2 Workflow Management and Description

References:

- *Open Modeling Interface and Environment (OpenMI) 1.4*
  http://www.openmi.org
- *Wf-XML 2.0*
- *http://www.wfmc.org/wfmc-wf-xml.html*
- *Enterprise Mashup Markup Language (EMML) v1.0*
- *http://www.openmashup.org*
- *Web Application Description Language*
- *http://www.w3.org/Submission/2009/SUBM-wadl-20090831/*
- *ISO/TS 8000-120:2009 "Data quality -- Part 120: Master data: Exchange of characteristic data: Provenance"*
  http://www.iso.org/iso/catalogue_detail.htm?csnumber=50801
- *The Open Provenance Model, v1.01*
  http://openprovenance.org/

Unlike in past Testbeds where there was detailed investigation of service-centric workflow and the chaining of geospatial algorithms, OWS-7 investigates the viability of managing workflow on the client.

The Workflow Management Coalition (WfMC)'s Workflow Standard – Interoperability Wf-XML Binding defines an XML language used to achieve a level of abstraction and independence from specific workflow engine implementations. The following diagram shows a representation of this integration approach that is based on the WfMC's Workflow Reference Model as shown in Figure 4-18.

In this diagram, Wf-XML supports the Interface 4. The goals of this standard are:

- Support chained, nested and parallel-synchronized models of interoperability
- Provide for both synchronous and asynchronous interactions
- Support individual and batch operations
- Remain implementation independent
- Define a light, easy-to-implement protocol

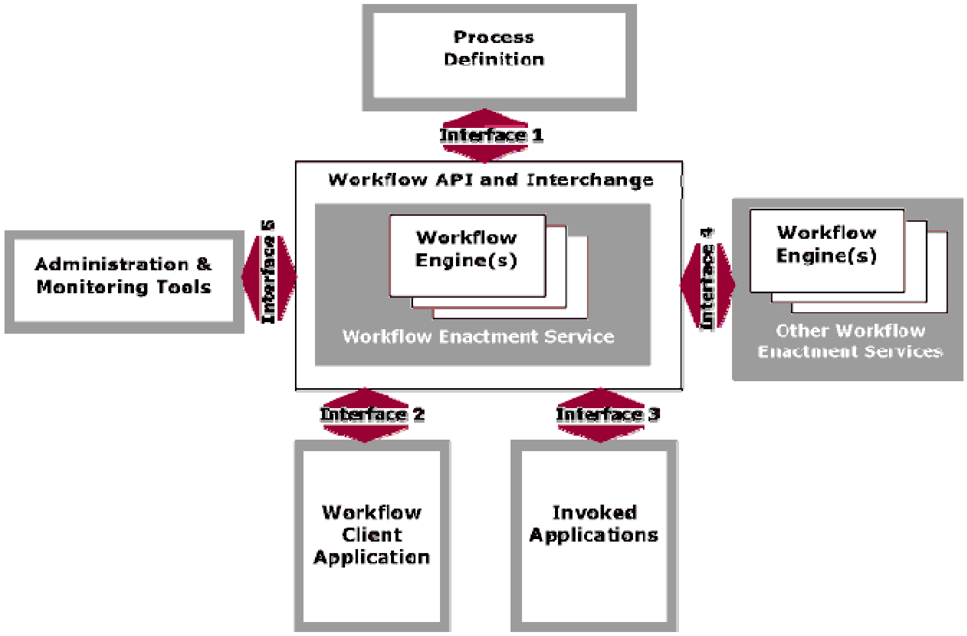

Figure 4-18. WfMC's Workflow Reference Model

4.3.6.3 GML 3.2.1

Reference:

- *OpenGIS® Geography Markup Language (GML) Encoding Standard 3.2.1, OGC Document 07-036*

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. Work to be performed in this thread shall use GML version 3.2.1 unless otherwise indicated. Note that many profiles of GML are still based on GML version 3.1.1, though some of these are in the process of revision. We encourage participants in OWS-7 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.

4.3.6.4 Authoritative Data Source Directory exemplar information sources

References:

- *OpenGIS Catalogue Service Implementation Specification, 2.0.2, 07-006r1*

The following are examples of socio-cultural data sources to be used in implementing the Authoritative Data Source Directory, and conducting Feature and Statistical Analysis.

Table 4-6. Socio-Cultural Information Sources

Title	Version	OGC Doc #
1) NationMaster.com; Nations of the World http://www.nationmaster.com/countries		
2) The Library of Congress, Global Gateway. Portals to the World http://www.loc.gov/rr/international/portals.html		
3) World Bank Countries and Regions http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/0,,pagePK:180619~theSitePK:136917,00.html		
4) United Nations Data Retrieval System UNESCO: http://data.un.org/Browse.aspx?d=UNESCO Energy: http://data.un.org/Browse.aspx?d=EDATA UNHCR: http://data.un.org/Browse.aspx?d=UNHCR Population: http://data.un.org/wiki/PopDiv.ashx		

4.3.7 FDF 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. For the FDF thread, those services include:

- Web Feature Service
- Web Processing Service
- Web Map Service
- Web Map Tiled Service

The FDF Clients access these services as well as other OWS services provided by other threads.

4.3.7.1 Web Mapping

References:

- *OpenGIS Web Map Service (WMS) Implementation Specification, 1.3.0, Document 06-042*
- *Candidate OpenGIS® Web Map Tile Service Implementation Standard, 1.0.0, Document 07-057r7*
- *OWS-6 DSS Engineering Report - SOAP/XML and REST in WMTS, 0.3.0, OGC Document 09-006*

OWS-7 requires a statistical mapping service be defined and implemented. It is believed that the best way to fulfill this requirement within the OGC architecture is to extend Symbology Encoding to better support statistical mapping requirements, and use the Feature Portrayal Service as the Web interface for requesting statistical, or thematic, maps.

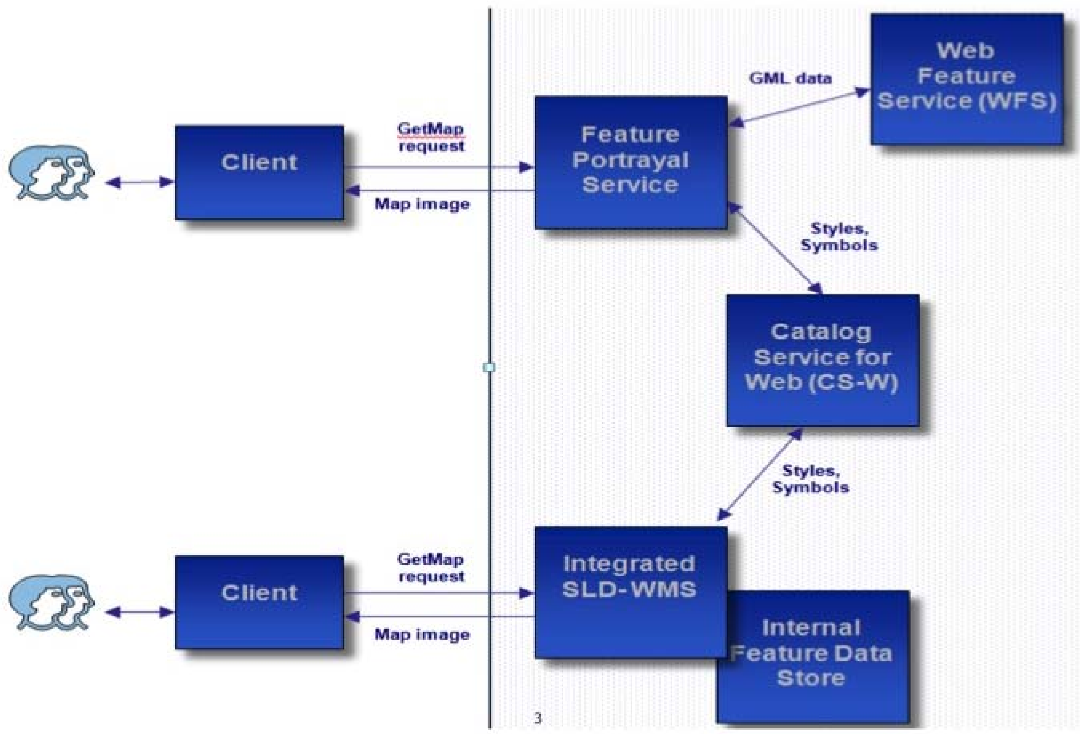

Figure 4-19. Comparison of component WMS and integrated WMS

The Web Map Tile Service (WMTS) addresses the scalability requirement that Web Mapping. Servers must be able to quickly return pre-rendered tiles without any image manipulation being necessary.

With the growing number of OGC web services being defined, implemented and deployed, and with client applications for these services becoming more and more sophisticated, it is becoming increasingly important to provide client applications with the ability to combine services. One way to provide this ability is to introduce an operation called GetAlternateSources, which, for a specified set of layers or feature types served by the server, reports other OGC web services that serve the same content (but perhaps in different forms). This would be a very useful operation, as it would essentially link services together. It would, for example, allow a client application to support browsing data on a WMTS server and then bridging over to the appropriate WFS server to download the actual features that are depicted in the map.

4.3.7.2 Web Features

References:

- *OpenGIS® Web Feature Service, 1.1, OGC Document 04-094*
- *OpenGIS Web Feature Service Implementation Specification (Corrigendum), 1.0.0, OGC Document 06-027r1*

The purpose of the Web Feature Server Interface Specification (WFS) is to describe data manipulation operations on OpenGIS® 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.

4.3.7.3 Web Processing

References:

- *OpenGIS® Web Processing Service, 1.0.0, OGC Document 05-007r7*
- *Corrigendum for OpenGIS Implementation Standard Web Processing Service 1.0.0, 0.0.8, OGC Document 08-091r6*
- *The OpenGIS Abstract Specification: Topic 1: Feature Geometry (ISO 19107 Spatial Schema) http://portal.opengeospatial.org/files/?artifact_id=1093&version=1*
- *A Critical Comparison of the 4-Intersection and 9-Intersection Models for Spatial Relations: Formal Analysis* http://mapcontext.com/autocarto/proceedings/auto-carto-11/pdf/a-critical-comparison-of-the-4-intersection-and%209-intersection-models.pdf*
- *Java Topology Suite http://www.vividsolutions.com/jts/jtshome.htm*
- *GRASS vector data processing http://grass.itc.it/grass70/manuals/html70_user/vectorintro.html and http://grass.itc.it/grass70/manuals/html70_user/vector.html*
- *Documenting Best Practices in Geospatial SOA through the Development of a Wetlands Permitting Solution http://www.fgdc.gov/grants/2008CAP/Reports/035-08-2-VA-FinalReport.pdf*
- *The Atom Publishing Protocol (RFC 5023) http://tools.ietf.org/html/rfc5023*

Unlike in past Testbeds where there was detailed investigation of service-centric workflow and the chaining of geospatial algorithms, OWS-7 investigates the viability of managing workflow on the client as described in the Information Viewpoint above. The Web Processing Service (WPS) is the key workflow-related service exercised in this Testbed. Participants will develop a FSA and Vector/Topology Profile(s) of the Web Processing Service.

The WPS is 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. This interface specification 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 a general-purpose web service in that it does not identify any specific processes that are supported. WPS can be thought of as an abstract model of a web service, for which profiles need be developed to support use, and standardized to support interoperability. As with other OGC specifications, it is the development, publication, and adoption of profiles that define the specific uses of this specification.

The WPS Vector/Topology Profile (WPS-VT) should define a set of spatial operations that are core building blocks for more complex geoprocessing algorithms. Candidate operations are listed here:

- Union
- Equals
- Disjoint
- Intersects
- Touches
- Crosses
- Disjoint
- Within
- Contains
- Overlaps
- Buffer
- Convex Hull
- Difference
- Nearest Neighbor
- Distance
- Generalize
- Dissolve
- Reclassify

For performing thematic, statistical, and FSA with WPS, further research is expected during OWS-7 to identify appropriate models and operations.

4.3.7.4 UML to GML Application Schema Processing and UGAS Tool

References:

- *OWS-6 GML Profile Validation Tool ER, 0.3.0, OGC Document 09-038r1*
- *Schematron http://www.schematron.com/*
- *Object Constraint Language Specification, 2.0*
- *OWS-5 GEOINT Schema Implementation Profile (GSIP) Schema Processing, 0.0.3, OGC Document 08-078r1*
- *OWS-5 Local MSD Implementation Profile for GML 3.2.1, 0.0.2, OGC Document 08-077*
- *OWS-5 Data View Architecture, 0.0.0, OGC Document 07-163*
- *OWS-3 Schema Tailoring and Maintenance, 0.0.7, OGC Document 05-117*
- *OWS-2 Application Schema Development, 0.0.4, OGC Document 04-100*

The UML to GML Application Schema (UGAS) tool also called ShapeChange, was originally developed as part of the GOS-TP initiative. 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 will be used to develop GML application schemas based on OGC's Geography Markup Language version 3.2.1 to encode NSG data and serve as a transfer format among NSG participants.

4.4 Aviation Thread

The Aviation Thread of OWS-7 builds on the Aeronautical Information Management (AIM) thread of OWS-6 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-7 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 such, it is expected that the results of the Aviation Thread of OWS-7 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.

4.4.1 Aviation Thread Scope

In OWS-7, the Aviation Thread will focus on investigating and demonstrating the applicability of AIXM and WXXM along with relevant OGC specifications and web services to applications and tools that support Airline Operations Centers and Flight Dispatch applications. Such applications provide information for representing a Common Operating Picture; supporting flight planning (including General Aviation) and preparation (MET and AIM); calculating weight and balance; estimating fuel requirements; in-flight emergency response; etc. As with OWS-6, the goal remains that of providing up-to-date aeronautical and weather information to users (such as pilots and flight dispatchers) and of supporting a variety of Aviation clients.

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 demonstration 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). The primary focus of the scenario(s) will be on ground usage of the information, and will include preparation of data for upload on Class 2 and General Aviation devices (including handheld Electronic Flight Bags (EFBs) and similar devices).

Towards that end, the OWS-7 Aviation Thread will cover the following tasks:

- Evaluation and advancement of AIXM, in the areas of using and testing new AIXM 5.1 features, developing components/tools for generating, validating, converting, and parsing AIXM, addressing feature metadata requirements and performance constraints, and supporting the portrayal of AIXM information.
- Evaluation and advancement of WXXM, focusing on the incorporation and demonstration new weather concepts such as the 4-D Weather Data Cube, including the impact of such concepts on the Event Notification Architecture, the support for probabilistic events, and the definition and usage of the time model in WXXM.
- Advancement of the Event Notification Architecture developed and exercised in OWS-6 to support multiple sources of events and multiple types of events and data changes (AIXM, WXXM), and to investigate different delivery protocols (push/pull), registration and

subscription lifecycle management approaches, and domain/schema-specific matching between events and subscriptions.

- Integration of AIXM/WXXM in the FAA SWIM environment, focusing on investigating approaches for leveraging SWIM Interface Management, Messaging and Security capabilities, as well as enabling Aviation clients to access SWIM services in addition to OGC services.

4.4.2 Aviation Thread Requirements

4.4.2.1 Evaluation and Advancement of AIXM

The US Federal Aviation Administration (FAA) and EUROCONTROL have developed AIXM as a global standard for the representation and exchange of aeronautical information. AIXM uses the OGC Geography Markup Language (GML 3.2) tailored to the specific requirements for the representation of aeronautical objects, including the temporality feature that allows for time dependent changes affecting AIXM features. FAA and EUROCONTROL are using AIXM as an integral part of their efforts to modernize their aeronautical information procedures and to transition to a net-centric, global aeronautical management capability.

The AIXM 5.1 Release Candidate 2 is currently available at www.aixm.aero and contains many enhancements to the prior version of AIXM, including concept review of schedules and temporality, harmonization of usage classes and concept review of notes and descriptions. The plan is to continue working on schema testing, bug fixes and editorial corrections until November 2009 when AIXM 5.1 will be finalized and frozen.

In OWS-7, the Aviation Thread will focus on four areas in evaluating and advancing AIXM:

1) Using and testing new AIXM 5.1 features in an OGC Web Services environment. Examples include but are not restricted to
    - Serving, filtering and updating AIXM 5.1 data via the OGC WFS-T interface,
    - Recommending guidelines or cross-walks for interpreting the new AIXM 5.1 schedules in conjunction with the Timeslice model in a web services environment
    - Recommending approaches for the management of value lists in AIXM (such as by leveraging the OGC Catalog Service for the Web (CSW) specification)
2) Developing components/tools for generating, validating, converting and parsing AIXM, in particular
    - Developing reusable (possibly open source) components/tools for validating and parsing AIXM (including business rules)
    - Developing reusable (possibly open source) components/tools that support the conversion of in-memory representations of aeronautical information to/from AIXM (enabling applications to serialize in-memory data to AIXM as needed)
    - Investigating capabilities of current schema generators to generate AIXM/EXI schemas from XMI
3) Addressing metadata requirements, in particular
    - Developing ISO 19139 schema that implements the metadata analysis document (http://www.aixm.aero/gallery/content/public/design_review_2/AIXM%205%20Proposal%20-%20Metadata%20-%2020060721.pdf) previously developed for AIXM

5.0 with an emphasis on meeting the use cases and addressing performance issues encountered in OWS-6 (such as java classes explosion and recursion)
    - This also includes investigating the requirements for data integrity/quality information and cyclic redundancy check (towards determining if the data was altered during storage/transport)
- Demonstrating the filtering and retrieval of information from a Web Feature Service (WFS) based on the metadata using the OGC Filter Encoding (FE) specification

4) Supporting the portrayal of AIXM information considering the use of the OGC Styled Layer Descriptor (SLD), and symbol and styling management architecture

FAA and EUROCONTROL may provide an AIXM set of files that contain sample aeronautical data (static and dynamic) as needed to support the AIXM testing and the thread scenario(s). The testbed participants may need to convert some existing source data into AIXM-compliant format.

4.4.2.2 Evaluation and Advancement of WXXM

FAA and EUROCONTROL have jointly developed WXXM as a proposed standard for the exchange of aeronautical weather information in the context of a net-centric and global interoperable Air Transport System (ATS). WXXM also uses GML (3.2) 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. The OGC's Technical Committee (TC) Meteorology Domain Working Group is in the process of setting up the appropriate mechanisms and interfaces between OGC and WMO to support this global harmonization and coordination effort.

In OWS-7, the Aviation Thread will evaluate WXXM within the context of new weather concepts such as the 4-D Weather Data Cube (Cube). The concept of the Cube is a key element of the Next Generation Air Transportation System (NextGen) vision. The Joint Planning and Development Office (JPDO) Weather Policy Study Team describes the Cube as a shared, 4-dimensional (three spatial dimensions and one temporal) database of weather information viewed as a conceptually unified source distributed among multiple, physical locations and suppliers. A portion of the Cube is a 4-dimensional weather Single Authoritative Source (SAS) defined as a network-enabled, machine-readable, geo- and time-referenced weather information that includes current observations, interpolated current conditions, and predictions of future conditions that support probabilistic decision aids and provide a seamless, consistent common weather picture that is available to all Air Traffic Management (ATM) decision makers for integration into operational decisions. Through the use of an architecture built on SOA principles and open standards, the Cube will function and appear to users as a single database.

OWS-7 will exercise and test WXXM version 1.1 and demonstrate the application of the 4-D Weather Data Cube in areas such as:

- Studying the impact of weather information available via the Cube on the Event Architecture (given that, unlike aeronautical events, weather events are not discrete events)
- Investigating if the current design of WXXM supports a user-oriented and efficient mechanism for how such probabilistic events could be dispatched and used

- Investigating the time model used in WXXM with respect to its ability to represent the different notions of time associated with meteorological information (e.g. issuing time, observation time, valid time, model run time, model cut-off time, etc)

As with AIXM, portrayal of WXXM will also be considered including the issues of symbol and styling management with consideration for the use of OGC SLD.

FAA and EUROCONTROL may provide weather data and events as needed to support the WXXM testing and the thread scenario(s). The testbed participants may need to convert some existing source data into WXXM-compliant format.

4.4.2.3 Advancement of the Event Notification Architecture

OWS-7 will advance and evolve the Event Notification Architecture exercised in OWS-6 to provide a more robust, sustainable and extensible framework for notifying users of changes to user-selected aeronautical and weather information, and to provide those users with access to the information changes automatically or on-demand. In particular, the Aviation Thread of OWS-7 will focus on

- Supporting multiple sources of events and data changes
- Supporting multiple types of events (aeronautical and weather) and data changes (AIXM and WXXM)
- Exercising Web Feature Service – Transactional (WFS-T) for posting aeronautical events to the AIXM database (s)
- Enhancing other aspects of the architecture by investigating different delivery protocols (push/pull), addressing registration & subscription lifecycle management requirements, incorporating domain/schema-specific matching between events and subscriptions, etc.

4.4.2.4 Integration of AIXM/WXXM in the FAA SWIM Environment

FAA and EUROCONTROL plan to use AIXM and WXXM in their System Wide Information Management (SWIM)-related components of the US NextGen and EU SESAR programs. It is expected that the results of the Aviation Thread of OWS-7 will be contributed to those programs with regard to recommendations on the applications of OGC specifications in the definition and implementation of SWI environments.

In OWS-7, the Aviation Thread will focus on investigating the integration of AIXM and WXXM in the FAA SWIM Environment. The FAA SWIM environment is an FAA enterprise IT infrastructure program that is implementing a system that will apply the Service Oriented Architecture (SOA) paradigm to National Airspace System (NAS) by utilizing state-of-the-art, net-centric, information management and exchange technologies. SWIM will accomplish its goals by providing IT infrastructure capabilities to the NAS enterprise in the form of Core Services and enterprise governance. The goals of the FAA SWIM include improved sharing of information (leading to better decision-making and operational effectiveness), improved systems integration (reducing functional redundancy and improving information quality), and greater flexibility to accommodate the system and operational changes required for NextGen. SWIM Core Services cover the following capabilities:

- Interface management (enabling Service Providers to expose services and Service Consumers to find those services)

- Messaging (enabling reliable message delivery and message routing, including metadata supporting routing and policy)
- Security (providing authorization-based access to data and services, and including ensuring confidentiality and information integrity)
- Enterprise Service Management (including Governance and Monitoring)

In OWS-7, the Aviation Thread will investigate the connection to the FAA SWIM environment from an OGC Web Services environment by leveraging existing SWIM services. In particular, OWS-7 will

- Investigate/leverage SWIM's approaches for dealing with security (including access control, authorization, and vulnerability), such as for data transmission between air and ground, and ground to ground.
- Investigate approaches for ensuring data integrity and assured delivery of information
- Investigate approaches for Aviation Clients to support access to different types of services: OGC services and SWIM services. This includes the approach of building proxy or bridge services to existing SWIM services to provide an OGC Service interface to those services

During the OWS-7 timeframe, two SWIM services/prototypes will be available for use by External Users: the Integrated Terminal Weather System Service (ITWS, providing access to real-time display of impacts of convective weather) and the Corridor Integrated Weather System (CIWS, providing access to current weather predictions and convective weather forecasts).

4.4.3 Aviation Thread Deliverables

The OWS-7 Aviation thread requires two types of deliverables

- **Engineering Reports and Documents:** 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.
- **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 11 in Section 3)).

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.

4.4.3.1 Engineering Reports (ERs) and Documents

The following Engineering Reports (ERs) will be developed in the Aviation thread and may be submitted to the OGC Specification Program at the completion of the OWS-7 Testbed. All documents created in response to this program will include "OWS-7" in the title, to facilitate later literature searches.

Table 4-7. Aviation Engineering Reports Required

1) OWS-7 Aviation ER covering a) Detailed technical architecture, including Event Notification Architecture b) AIXM 5.1 and metadata assessment and recommendations c) WXXM 1.1 and new concepts assessment and recommendations d) FAA SWIM integration results, issues and recommendations (including assessment of security vulnerabilities, requirements and capabilities, and the extent to which they can be leveraged in OWS-7) e) Final Aviation scenario(s) and use cases as developed/refined by participants and sponsors during OWS-7
2) OWS-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 3.2 Profiles d) OGC Web Services (such as WFS, Filter Encoding, Event Service, etc) e) SWIM Services f) 4-D Weather Data Cube
3) OWS-7 AIXM 5.1 Schema (ISO 19139 schema profile); WXXM 1.1 Schema

4.4.3.2 Services, Clients and Tools

Implementations of the following services, clients and data instances will be developed in the AIM thread for integration and interoperability testing and may be invoked for cross-thread scenarios for OWS-7 demonstration events (Note that Deliverable 11 Reusable AIXM Handling Components/Tools will be delivered as executable or source code depending on the software license for reuse beyond OWS-7):

Table 4-8. Aviation Services, Clients and Tools Required

1) One or more AIXM 5.1 WFS-T 2.0 with Filter Encoding Support to serve the AIXM 5.1 data (including metadata) and to support the posting of events to the AIXM datastore	Service
2) One or more WXXM 1.1 WFS 2.0 (or other OWS as applicable) to serve the WXXM 1.1 data	Service
3) Feature Portrayal Service (FPS) for AIXM, WXXM	Service

4) Event Notification Architecture components to satisfy the Event Notification Requirements (may include Broker component, Router component, Registration and Lifecycle management component, etc as prescribed in the architecture to be developed in OWS-7)	Components
5) Registry Service for symbols, styles, and code lists for AIXM and WXXM	Service
6) One or more bridge or proxy service(s) to available SWIM services as needed to support the OWS-7 Aviation technical architecture	Service
7) Security architecture components as feasible depending on the investigation of SWIM capabilities and the extent they can be leveraged in the OWS-7 Aviation Thread	Components
8) One or more EFB Class 2 and/or Class 3 Aviation Client(s) and/or hand-held electronic display device component(s) (or their surrogates) to support a) OGC Web Services (WFS-T, WCS, WMS, FPS and/or CSW) to retrieve, integrate and portray aeronautical and weather information affecting certain designated areas within given time intervals meeting certain user-defined filters b) Connection to a development/in-progress version of the 4-D Weather Data Cube since the Cube will not be fully established nor operational within the OWS-7 timeframe c) The Event Notification architecture components d) Connection to available SWIM services e) The security architecture, if feasible based on the recommendations of the investigations f) One or more Aviation Thread scenario	Client
9) One or more Dispatch Aviation Client(s) to support the same requirements as above in addition to representing and maintaining the Common Operating Picture	Client
10) One or more reusable AIXM handling components/tools and associated documentation for validating, parsing and converting AIXM data and for generating/mapping AIXM/EXI schemas	Tools

4.4.4 Aviation Thread Enterprise Viewpoint

According to the FAA web site immediately below, 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. See:

http://www.faa.gov/news/fact_sheets/news_story.cfm?newsId=8807

To address these global problems, both the US's FAA and Europe's EUROCONTROL are working on Air Traffic Management (ATM) modernization expanding capabilities to maintain the safety and efficiency of global aviation. This involves working towards a vision of an evolving global Aeronautical Information Management paradigm (Figure 4-20) built extensively on standards, digital data exchange and process automation to provide amongst others

- End to end management of information,
- Support for a common operating picture collecting system information and feeding the right information to the right place at the right time,
- Improved predictability through better information integration,
- Value to customers for using information in flight planning, navigation, rerouting and setting adaptation to various tools.

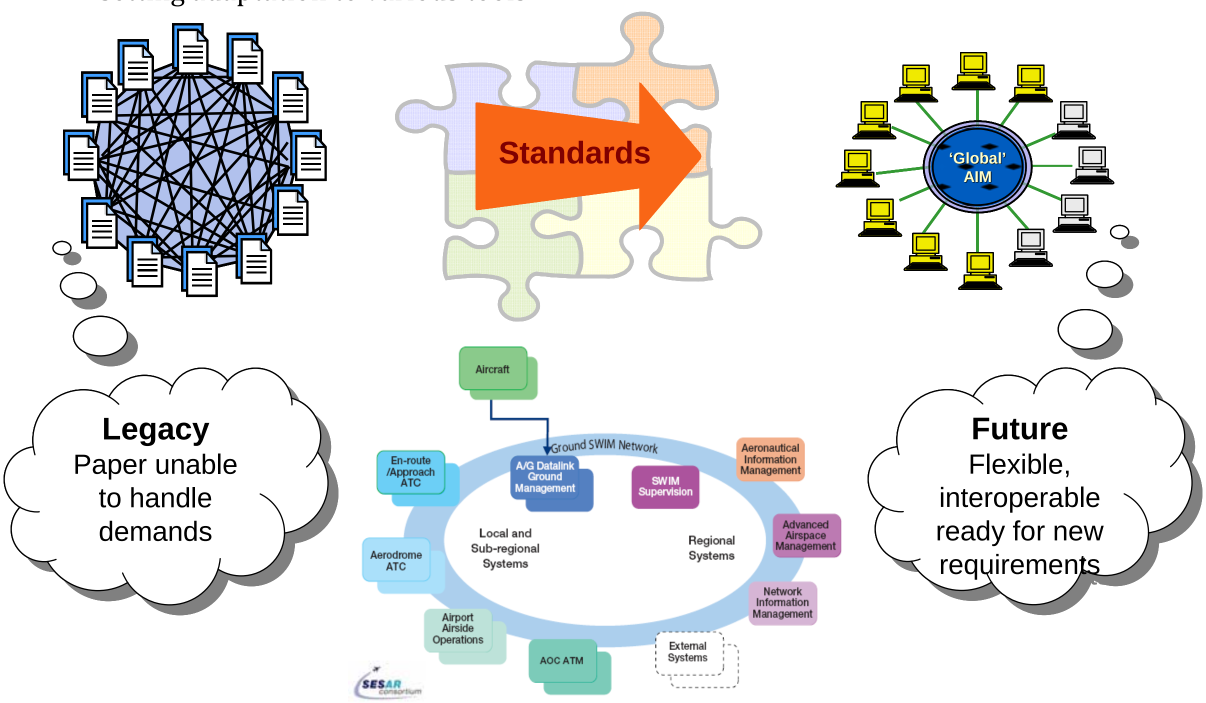

Figure 4-20. Towards a New Aeronautical Information Management Paradigm

At the heart of this new AIM paradigm is the Aeronautical Information Exchange Model (AIXM) (Figure 4-21). 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 and NGA and others (Figure 4-22).

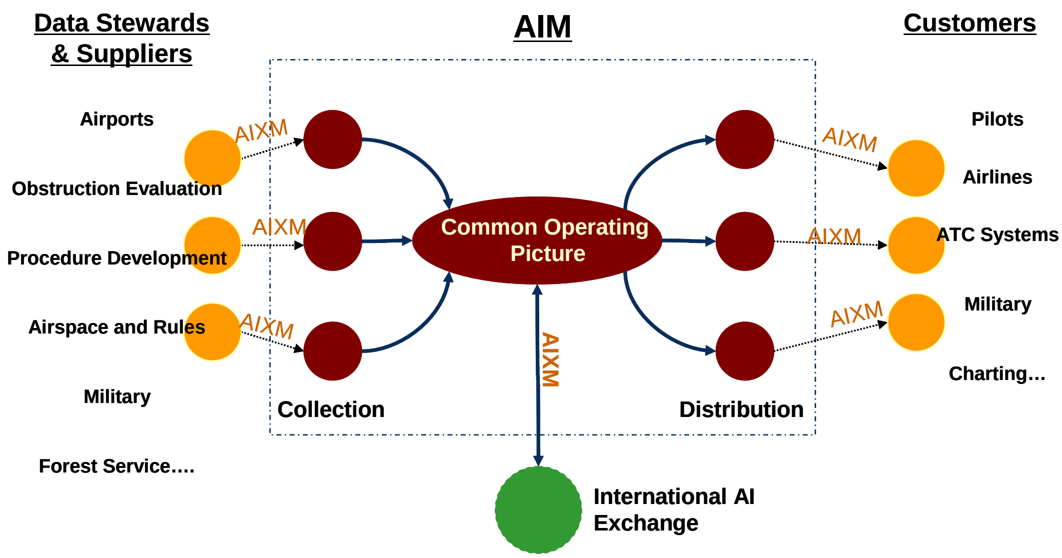

Figure 4-21. AIXM in Support of New AIM Paradigm

Figure 4-22. AIXM Overview

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

4.4.4.1 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 4-23). 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.

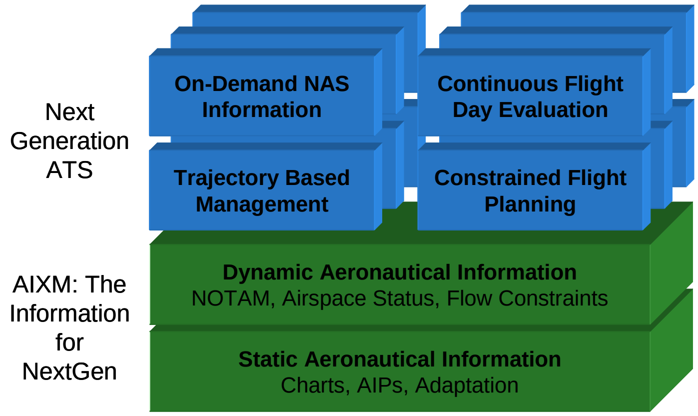

Figure 4-23. AIXM as the Foundation for NextGen

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.

NNEW is the program within FAA that is managing the development of the FAA portion of the 4-Dimensional Weather Data Cube (Cube) shown in Figure 4-24), an infrastructure being set up in collaboration with the National Oceanic and Atmospheric Administration (NOAA) and the Department of Defense (DoD). The Joint Planning and Development Office (JPDO) Weather Policy Study Team describes the Cube as a shared, 4-dimensional (three spatial dimensions and one temporal) database of weather information viewed as a conceptually unified source distributed among multiple, physical locations and suppliers. A portion of the Cube is a 4-dimensional weather Single Authoritative Source (SAS) defined as a network-enabled, machine-readable, geo- and time-referenced weather information that includes current observations, interpolated current conditions, and predictions of future conditions that support probabilistic decision aids and provide a seamless, consistent common weather picture that is available to all Air Traffic Management (ATM) decision makers for integration into operational decisions.

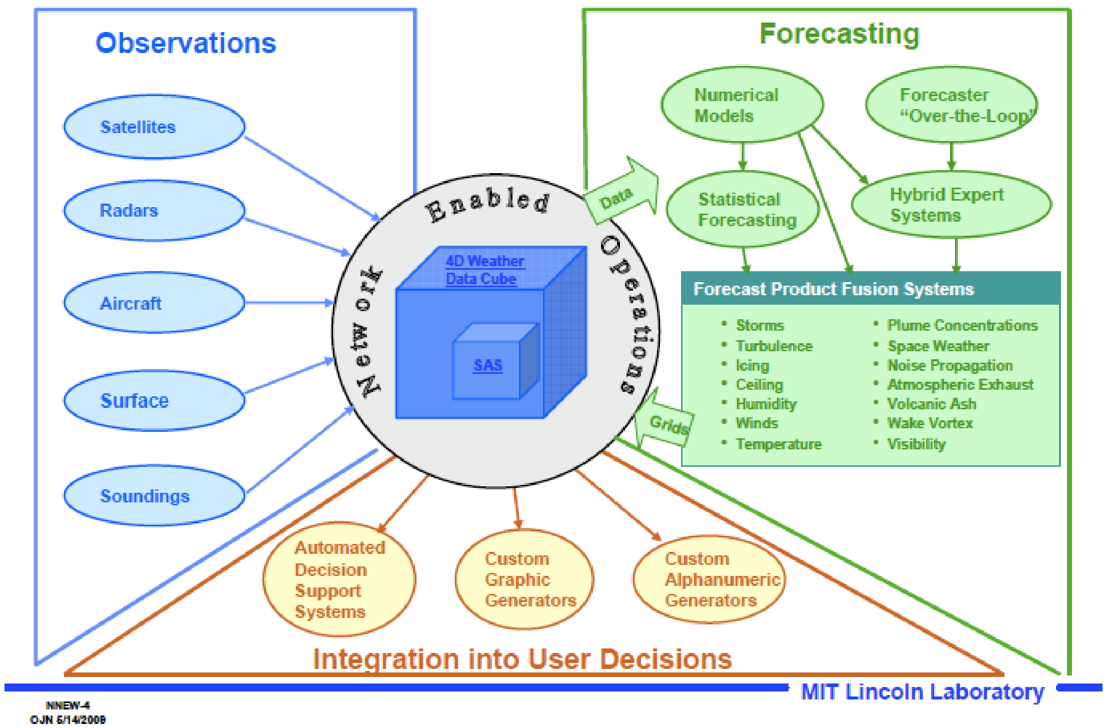

Figure 4-24. The 4-D Weather Data Cube

4.4.4.2 Single European Sky ATM Research (SESAR)

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

SESAR is a Joint European Commission/Eurocontrol initiative (currently in the Development phase according to Figure 4-25) 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 4-25. SESAR Phases

The SESAR Master Plan also states that "European ATM should be considered as a virtual single enterprise in which constituent parts work together in a networked (net-centric) service-based operation". The goal is to achieve that using an overall information architecture based on the concept of SWIM (Section 4.4.4.3). The SWIM concept is required for building the net-centric environment and enterprise architecture (a light-weight, massively distributed, horizontally applied architecture that distributes components and/or services across an enterprise's information value chain using internet technologies and other network protocols as the principal mechanism for supporting the distribution and processing of information services.

4.4.4.3 System Wide Information Management (SWIM)

In SESAR, 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;
- An access to the SWIM physical network.

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 National Airspace System (NAS)-wide information web to connect Federal Aviation Administration (FAA) systems to one another, and enable interaction with other members of the decision-making community. 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.

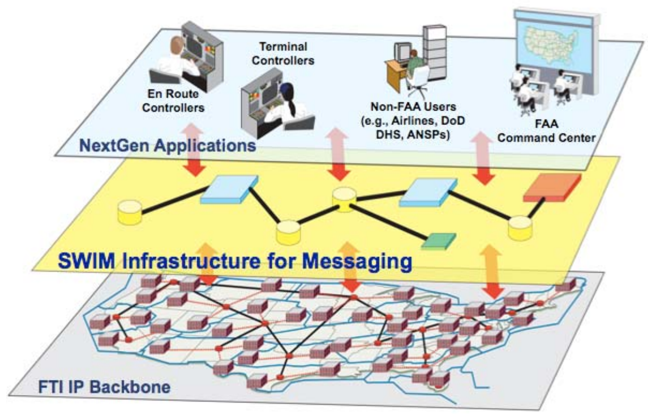

Figure 4-26. FAA SWIM Conceptual Overview

SWIM will deliver the full set of capabilities in three "segments". Segment 1 is planned for implementation in the time period 2009-2013. The focus of this segment is on the implementation of 9 core capabilities shown below in blue. Segment 2 is likely to start in 2012 followed by Segment 3 in approximately 2015.

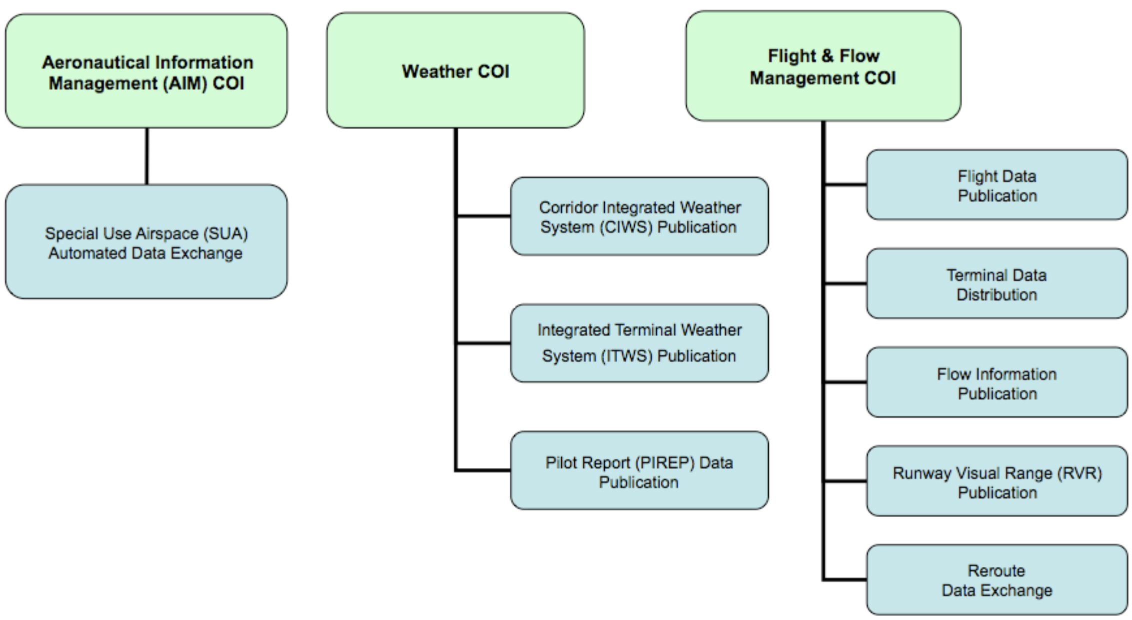

Figure 4-27. FAA SWIM Segment 1 Capabilities

4.4.4.4 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-7, 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-7. This includes exercising a variety of web services utilizing AIXM and WXXM encodings (including digital NOTAMs, information about field conditions and relevant meteorological information) for supporting Airline Operations Centers/Flight Dispatch applications.

Note: The scenarios are subject to change as determined by various factors, most notably availability of AIXM and weather data. The scenarios will be refined by the sponsors and the OWS-7 participants at the kickoff and during the initiative.

The purpose of the aviation thread of OWS-7 is to extend the use of OGC Web Services to applications that support flight dispatch operations. 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 are 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 is 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 are 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 downloads the flight-briefing package to his Electronic Flight Bag (EFB) using web services. The pilot can 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. The scenarios should also demonstrate a pilot side client with more limited capabilities that can be hosted in a hand-held device.

During pre-flight briefing and flight-following flight dispatchers and pilots communicate either by voice (Satellite/VHF/HF) or by exchanging short text messages via the ARINC or SITA Aeronautical Communications Addressing and Reporting System (ACARS). The scenarios will demonstrate the use of web services messaging to supplement voice and ACARS. The pre-flight briefing phase of the scenarios will demonstrate a capability for the flight dispatcher or the pilot to point out to the other specific aeronautical or weather data that may clarify some point under discussion. This may be done by either one transmitting to the other URI(s) that may be used to retrieve that data.

Aircraft and crew profiles are stored in the OWS Flight Dispatch Center database, and are used to filter data displayed to the dispatcher and the crew. Additional safety risk parameters regarding the probability of specific weather hazards are selectable. The flight dispatcher has a web services client on his workstation that enables him to access databases of aeronautical and weather information via WFS servers.

The details of the scenarios can be found in Appendix A of the Aviation Thread Section, page 108.

4.4.5 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, WXXM, GML, EXI, ISO 19139 Metadata XML).
- Information filtering, integration, styling and sharing (Filter Encoding, OWS Context, OGC KML, SLD, GeoRSS).

4.4.5.1 AIXM

Relevant Specifications: AIXM 5 (http://www.aixm.aero)

-

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 4-28), 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.

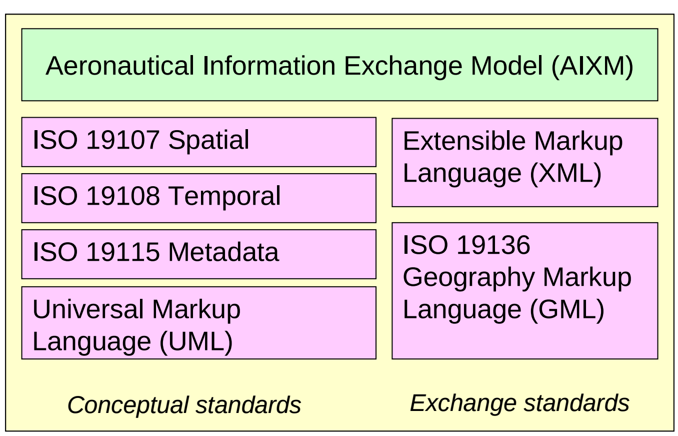

Figure 4-28. AIXM Based on International Standards

AIXM 5.0 is divided into 11 conceptual areas (Aerodrome/Heliport, Airspace, Holding, Navaids and Points, Obstacles, Organizations, Procedures, Refueling Aerial, Routes, Services, and Surveillance) and 4 shared components (Geometry, Notes, Time Management, Aircraft). Those areas are not independent from each other and are related via a high number of associations that cross the boundaries of each area.

AIXM 5.0 has been used in a number of trials and initial implementations (OGC OWS-6, Digital NOTAM, procedure design and charting, etc.). This has enabled the community to identify some bugs, model deficiencies and areas requiring further clarifications. The AIXM 5.1 Release Candidate 2, now available at http://www.aixm.aero, contains many enhancements to AIXM 5.0 as requested by the AIXM community. Some key features of AIXM 5.1 are

- Schedules and Temporality – concept review
- Harmonization of Usage classes
- Notes and descriptions – concept review

A complete list of AIXM 5.1 changes is posted at https://extranet.eurocontrol.int/http://prisme-oas.hq.corp.eurocontrol.int/aixmwiki_public/bin/view/AIXM/AIXM_5_1_changes.

The opportunity to report bugs and bug fixes as well as recommend editorial corrections remains open until November 2009, when AIXM 5.1 will be frozen.

4.4.5.2 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).

4.4.5.3 GML

Relevant Specifications: OpenGIS® Geography Markup Language (GML) Encoding Specification 3.2.1 (OGC document 07-036)
http://portal.opengeospatial.org/files/?artifact_id=20509&version=1

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.

4.4.5.4 EXI

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

EXI is 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.

4.4.5.5 ISO 19139 Metadata XML Schema Implementation

Relevant Specifications: ISO/TS 19139:2007 – Geographic Information – Metadata – XML Schema Implementation

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 ISO 19139 schema will be used to encode metadata associated with AIXM 5 data, and to implement the metadata analysis document previously developed for AIXM 5.0 (http://www.aixm.aero/gallery/content/public/design_review_2/AIXM%205%20Proposal%20-%20Metadata%20-%2020060721.pdf) with an emphasis on meeting the use cases and addressing performance issues (such as java class explosion and recursion).

The ISO 19139 schema will also be leveraged to address data integrity/quality information and cyclic redundancy checks (towards determining if the data was altered during storage/transport)

4.4.5.6 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.

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

4.4.5.7 OWS Context

Relevant Documents:

OGC Web Services Context Documents (OWS Context 0.2) Interoperability Experiment: FINAL REPORT (http://portal.opengeospatial.org/files/?artifact_id=12015&version=1)

OWS Context document is an XML encoding that references remote and/or local OGC Web Services. OWS Context documents are related to, but more powerful than, Web Map Context Documents (05-005). The latter are limited to referencing OGC Web Map Services (WMS), whereas the former can reference other OGC Web Services such as Web Feature Services (WFS), and Web Coverage Services (WCS).

The OWS Context can be used by the Aviation Client as the basis for integrating, visualizing and sharing aeronautical and weather information.

4.4.5.8 OGC KML

Relevant Specifications:

- *OGC KML 2.2 (http://www.opengeospatial.org/standards/kml/)*

OGC KML is an XML-based encoding schema for expressing geographic annotation and visualization on existing or future web-based online maps and Earth browsers (that 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).

4.4.5.9 SLD

Relevant Specifications & Documents:

- *ISO 19117:2005 – Geographic Information- Portrayal*
- *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 intent in the Aviation Thread of OWS-7 is to experiment with 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 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.

Within the Aviation domain, the G-10W (Aerospace Behavioral Engineering Technology – Weather Information Systems; see http://www.sae.org/servlets/works/committeeResources.do?resourceID=118173) committee group of SAE (Society of Automotive Engineers) is currently formulating a list of weather elements that will be considered as potential symbol recommendations to the community. Another SAE committee is planned to be established in 2010 to address temporary aeronautical data symbology. It remains open whether the SAE initiatives can be leveraged in time for OWS-7 work and demonstration.

4.4.5.10 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.

4.4.6 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, those services are

- Web Feature Service (WFS) for access to aeronautical and weather information, and for access to the development/in-progress version of the 4-D Weather Data Cube,
- Web Coverage Service (WCS) for possible access to weather information (via the development/in-progress version of the 4-D Weather Data Cube or available SWIM Weather services)
- 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) and other services as needed to support the Event Notification Architecture
- Catalog Service for the Web (CSW) for managing publication, discovery and access to symbols, styles and code lists for AIXM and WXXM
- 4-D Weather Data Cube access

- FAA SWIM services

4.4.6.1 Web Feature Service

Relevant Specifications:

- *OGC Web Feature Service 2.0; ISO 19142 Geographic Information – Web Feature Service (http://www.isotc211.org/protdoc/211n2632/; final version submitted to ISO also available on OGC Pending Documents page at http://portal.opengeospatial.org/files/?artifact_id=32679&version=1)*

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 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).

4.4.6.2 Web Coverage Service

Relevant Specifications:

- *OGC Web Coverage Service specification v 1.1.2* http://portal.opengeospatial.org/files/?artifact_id=27297

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.

The WCS interface may be exercised in the Aviation thread to access data via the 4-D Weather Data Cube or one of the FAA SWIM Weather Services (ITWS or CIWS). Note that, although planned, ITWS and CIWS won't deliver their products in WXXM in time for OWS-7.

4.4.6.3 Feature Portrayal Service

Relevant Specifications & Documents:

- *- 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)*

The Feature Portrayal Service (FPS) is a type of Component Web Map Service (WMS) that can symbolize feature data obtained from one ore more remote WFSs. It allows for easy and straightforward binding of arbitrary GML data source and applicable styling rules. Typically, an FPS has the following characteristics:

- It has no pre-defined 'named' styles of layers (i.e. it acts as a portrayal engine rather than a data source).
- It only supports the WMS interface.
- It can symbolize feature data from any compliant WFS or GML data provided inline.
- It supports both user-defined styles and user-defined layers.

The styles and symbols can be stored in a Catalog Service for the Web (CSW) as shown in Figure 4-29.

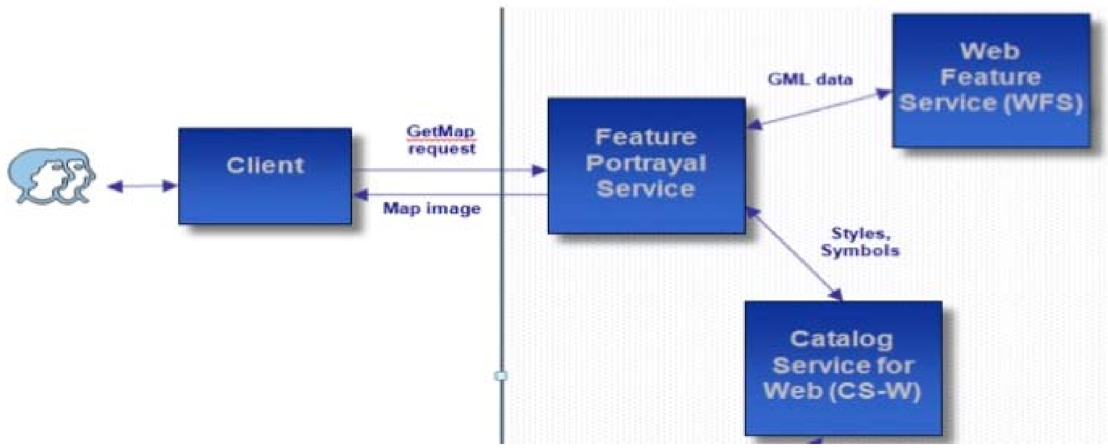

Figure 4-29. Feature Portrayal Service

The intent in the Aviation Thread of OWS-7 is to experiment with 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.

4.4.6.4 Event Service

Relevant Documents:

- *OWS-6 AIM Event Service (http://portal.opengeospatial.org/files/?artifact_id=33208&version=1)*
- *OGC 08-133 Sensor Event Service (http://portal.opengeospatial.org/files/?artifact_id=29576&version=2)*
-

In OWS-6, an AIM Event Service was developed, based on the Sensor Event Service (SES), that allows information producers to publish notifications/events (Digital NOTAMs generated by the AIXM WFS) and then notifies information consumers (Aviation Clients) of events that match their subscription criteria (Figure 4-30).

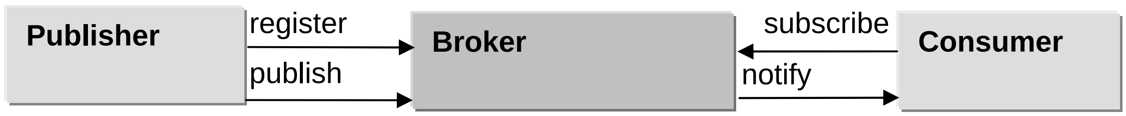

Figure 4-30. OWS-6 AIM Event Notification System Overview

In OWS-6, the AIM Event Service only supported the brokering of Digital NOTAM notifications, and was based upon the WS-* standards from OASIS and W3C (including WSDL, SOAP and WS-Resource). The OWS-7 Aviation Thread will build on the OWS-6 Event Service (possibly resulting in the development of multiple components in support of an Event Notification Architecture) to support multiple sources and types of events (aeronautical and weather), investigate different delivery protocols (push/pull), address registration & subscription lifecycle management, and support domain-specific/schema-specific matching between events and subscriptions.

4.4.6.5 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.

The OASIS WS-Notification family of specification may be used in the Aviation thread to support the mechanism of notifying clients of data change or availability.

4.4.6.6 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. The WNS may be used in the Aviation thread to support the Event Notification Architecture of notifying clients of data change or availability.

4.4.6.7 Catalog Service for the Web

Relevant Specifications:

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

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 Catalog Service for the Web (CSW) represents the HTTP protocol binding in version 2.0.2. In OWS-7, the CSW may be used to register, manage, discover and access symbols, styles and code lists for AIXM and WXXM.

4.4.6.8 4-D Weather Data Cube Access

The concept of the Cube is a key element of the US NextGen vision. The Joint Planning and Development Office (JPDO) Weather Policy Study Team has described the Cube as a shared, 4-dimensional (three spatial dimensions and one temporal) database of weather information viewed as a conceptually unified source distributed among multiple, physical locations and suppliers. Another aspect of the Cube concept, as identified by the Weather Policy Study Team is that a portion the Cube is "a 4-Dimensional Weather Single Authoritative Source (SAS)." The SAS is defined as network-enabled, machine-readable, geo- and time-referenced weather information that includes current observations, interpolated current conditions, and predictions of future conditions that support probabilistic decision aids and provide a seamless, consistent common weather picture that is available to all Air Traffic Management (ATM) decision makers for integration into operational decisions.

The distributed nature of weather data makes the Cube a virtual database that will be composed of multiple, physical databases maintained at different locations. Through the use of an architecture built on SOA principles, the Cube will function and appear to users as a single database. The actual physical locations of the data sources will be transparent to the users (Figure 4-31). This distributed service model is in keeping with the net-centric dissemination vision of NextGen. The Cube will leverage and utilize the SWIM System within the FAA.

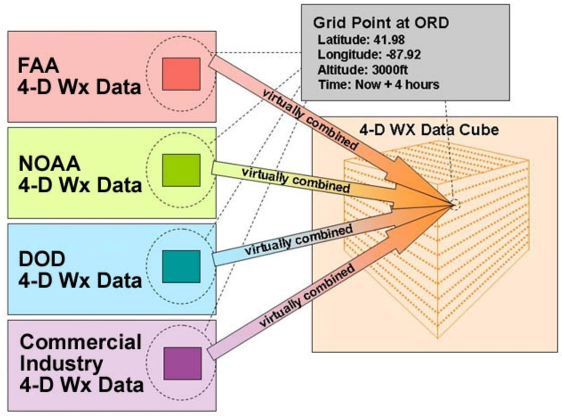

Figure 4-31. Conceptual View of the 4-D Weather Data Cube

Figure 4-32 depicts the architectural framework for the Cube as comprised of four layers: an Applications Layer, a Weather Services Layer, a Core Services Layer and a Multiple Enterprise Telecommunications Infrastructure (METI) Layer. The METI Layer provides the physical telecommunications networking and monitoring capabilities facilitated by the Core Services Layer. The Core Services Layer is comprised of the foundations of an IT system, the SWIM system, built within a Service Oriented Architecture (SOA). The Weather Services Layer is then built on top of the Core Services Layer to provide the infrastructure necessary to connect and adapt to providers and consumers in the Applications Layer. The Weather Services Layer enhances the capabilities of the Core Services Layer with the addition of weather specific standards, formats, and infrastructure. The combination of these additional components will provide the ability to discover Cube data using SAS concepts, the ability to access data using *what, where, when* queries, and the ability to support those capabilities in a scalable manner.

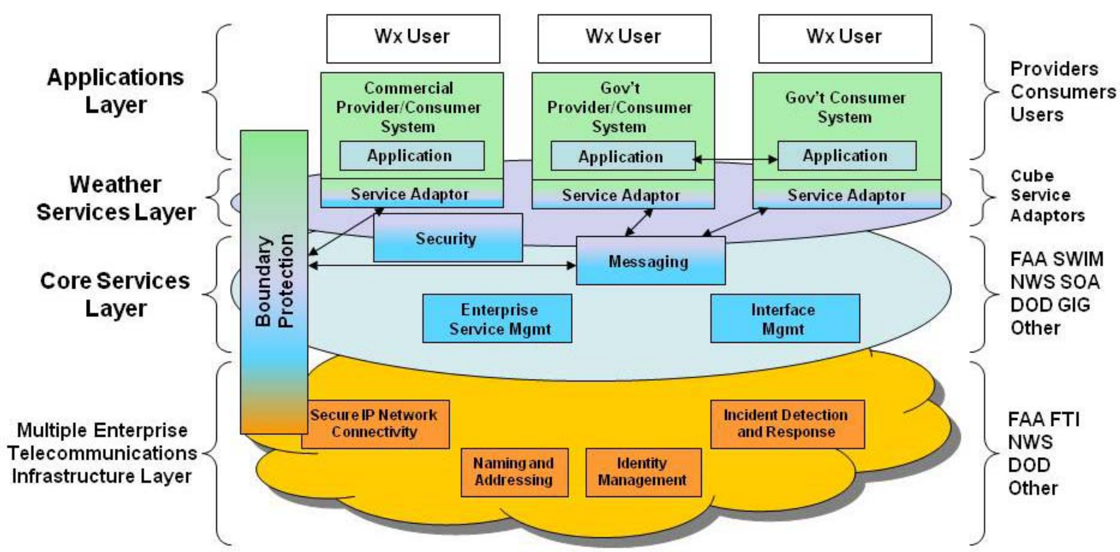

Figure 4-32. The Cube's 4 Architectural Framework Layers

The Cube will employ a hub and spoke model of data distribution to effectively disseminate its data to customers. That model involves the deployment of Origin Servers (shown in simplified view in Figure 4-33). In terms of the Cube's use of OGC Web Services, Figure 4-33 shows how the Geospatial Data Access Service is broken down into a data store and a Reference Implementation (RI) that provide the service interface. The Cube's RI are implemented based on the WCS/WFS OGC standards to accommodate different data models and formats. More information about the Cube's architecture can be found at (URL to be provided by NNEW).

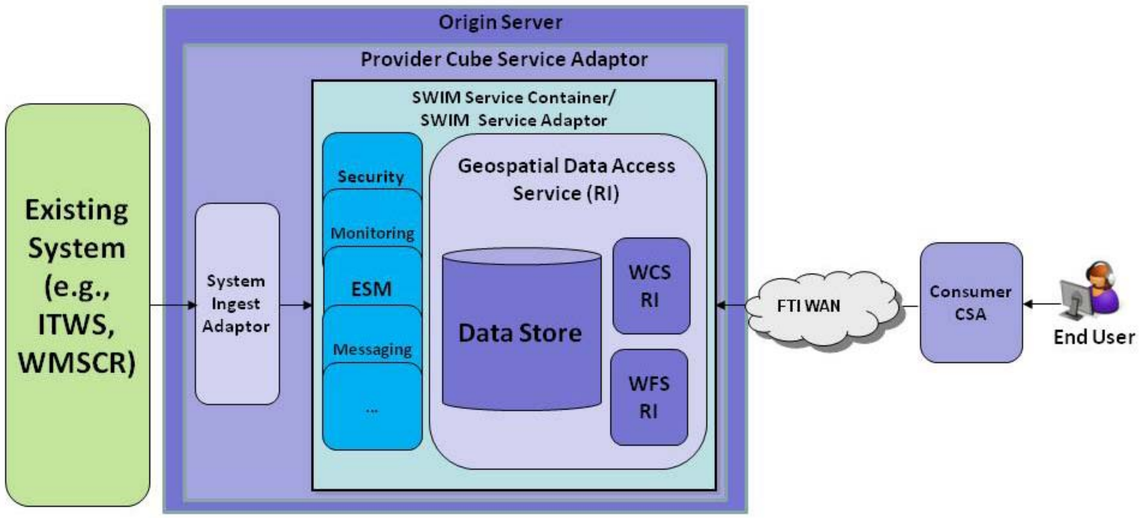

Figure 4-33. The Cube's Use of OGC Standards

4.4.6.9 FAA SWIM Services

SWIM is an FAA enterprise IT infrastructure program that is implementing a system that will apply the SOA paradigm to NAS applications by utilizing state-of-the-art, net-centric, information management and exchange technologies. SWIM will accomplish its goals by providing IT infrastructure capabilities to the NAS enterprise in the form of Core Services and enterprise governance. Core Services enable "business services" to be available throughout the enterprise while maintaining loose-coupling and maximizing reuse and consistent implementation. SWIM will define and approve standards for Core Services to enable NAS applications to expose their products and data as NAS business services. SWIM Core Services include the following:

Interface Management includes interface specification and interface discovery as well as support for managing the schemas that define data format and semantics for interface data elements. Interface Management also covers the runtime capability provided by Service Invocation which covers the connectivity and communication aspects of core services.

Messaging covers how data are passed between applications. It includes how the data envelope is structured (SOAP) and how metadata supports content based routing and policy. It also covers reliable delivery.

Security covers how both service consumers and providers authenticate themselves, assert privileges, and provide confidentiality for invoking and consuming services at both the application endpoint and security levels.

Enterprise Service Management has two aspects. The first is how services are governed. This includes managing the development, deployment, operation, and retirement phases of a service. Services are managed based on the required Quality of Service (QoS) as expressed by a Service Level Agreements (SLA) between the service provider and potentially many service consumers. The other aspect of Enterprise Service Management is how the operational system is monitored to ensure that SLAs are being met.

The SWIM technical architecture framework is shown in Figure 4-34.

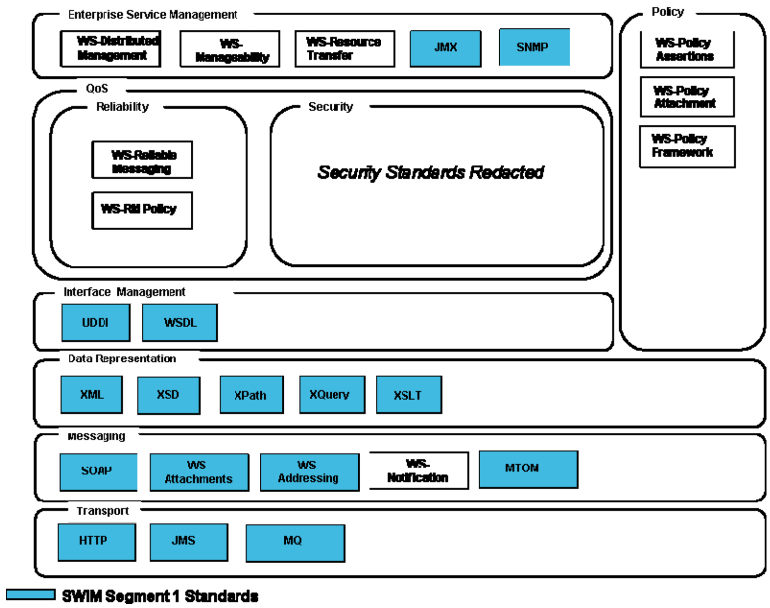

Figure 4-34. FAA SWIM Technical Architecture Framework

According to the SWIM Technical Overview document, only a subset of SWIM services will be made available to External User systems, see: (http://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/techops/atc_comms_services/swim/documentation/media/architecture/SWIM%20Tech%20Overview%20V2_1%2028Mar2008.doc)

- The Integrated Terminal Weather System (ITWS) integrates terminal weather data to automatically provide current weather information and predictions in easily understood graphic and textual form, including windshear and microburst predictions, storm cell and lightning information and terminal area winds aloft. It provides a 60-minute forecast of anticipated weather conditions. ITWS uses WCS/WFS as one of its service interfaces. Although planned, ITWS will not provide data back in WXXM in time for use in OWS-7.
- The Corridor Integrated Weather System (CIWS) provides advanced weather product generation to help air traffic users reduce convective weather delays. CIWS provides national, en route, and terminal air traffic flow managers and airline system operation centers with automated, rapidly updated weather information as well as weather products including storm locations, radar measured storm tops, and two-hour storm forecasts including storm growth and decay. A prototype service will be available for use and accessible in OWS-7. CIWS also uses WCS/WFS as one of its service interfaces. Although planned, CIWS will not provide data back in WXXM in time for use in OWS-7.

- The Special Use Airspace (SUA), for serving, posting, updating and notifying users of SUAs schedules and status (SUAs are regions of airspace designated, during certain times of day, to be used by the military in the service of national defense (to ensure that no other air traffic in the area occurs during these times). It is not yet confirmed whether this service will be available for use and accessible in OWS-7.

For more information on SWIM, refer to the SWIM website http://www.swim.gov.

4.4.7 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 relates these to specific components linked by a communications network.

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 4-35 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, Figure 4-35 does not show all possible interactions amongst the identified components.

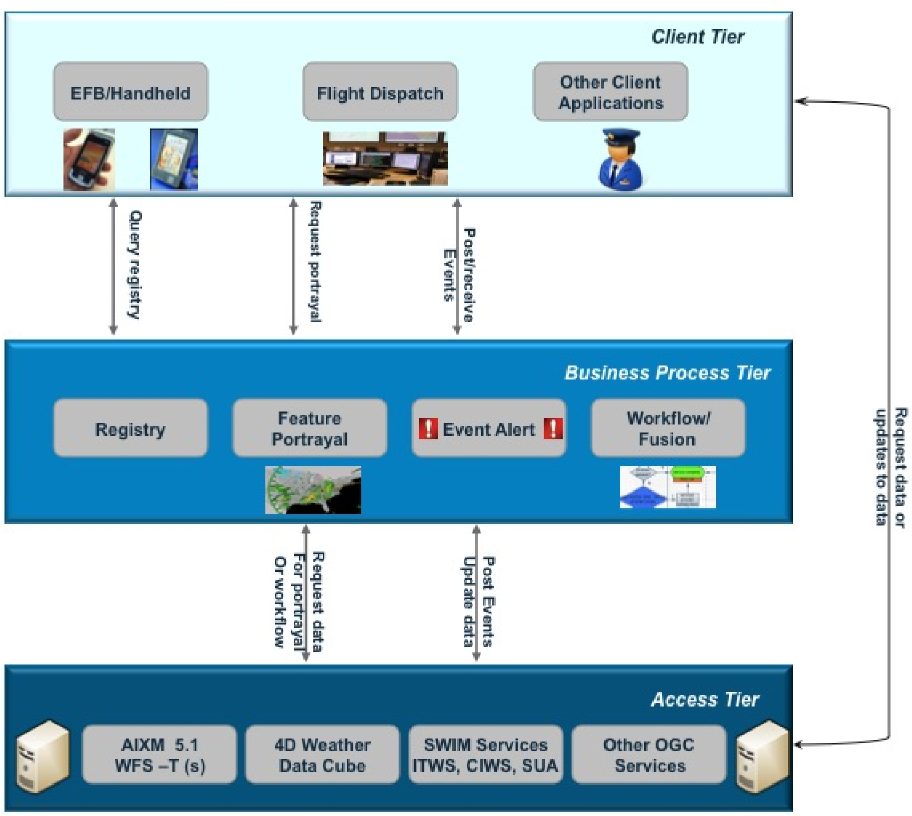

Figure 4-35. AIM Engineering Viewpoint

4.4.8 Aviation Thread Appendix A: Scenarios

The purpose of the aviation thread of OWS-7 is to extend the use of OGC Web Services to applications that support flight dispatch operations. *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.

Using scenarios described below the OWS-7 aviation thread will demonstrate the use of OGC web services to provide 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 are 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 is 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 are 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 downloads the flight briefing package to his Electronic Flight Bag (EFB) using web services. The pilot can 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. The scenarios should also demonstrate a pilot side client with more limited capabilities that can be hosted in a hand-held device.

During pre-flight briefing and flight-following flight dispatchers and pilots communicate either by voice (Satellite/VHF/HF) or by exchanging short text messages via the ARINC or SITA Aeronautical Communications Addressing and Reporting System (ACARS). The scenarios will demonstrate the use of web services messaging to supplement voice and ACARS. The pre-flight briefing phase of the scenarios will demonstrate a capability for the flight dispatcher or the pilot to point out to the other specific aeronautical or weather data that may clarify some point under discussion. This may be done by either one transmitting to the other URI(s) that may be used to retrieve that data.

Aircraft and crew profiles are stored in the OWS Flight Dispatch Center database, and are used to filter data displayed to the dispatcher and the crew. Additional safety risk parameters regarding the probability of specific weather hazards are selectable. The flight dispatcher has a web services client on his workstation that enables him to access databases of aeronautical and weather information via WFS servers.

The Flight Dispatcher at the OWS Flight Operations Center starts his shift at $\mathbf{T_1}$ -2 hours UTC and finds that he is responsible for providing preflight briefing packages and flight following services to the following aircraft that are due to depart within the next 8 hours:

- OWS-7A, an EJR-145 type aircraft flying a scheduled route from to **{$\mathbf{TBD_1}$}** to **{$\mathbf{TBD_2}$}** with 140 passengers**.**
- OWS-7C, a single engine turboprop, type PC12, flying an on-demand air taxi flight from **{$\mathbf{TBD_5}$}** to **{$\mathbf{TBD_6}$}**
- OWS-7D, a twin engine propeller aircraft, type BE58, owned by OWS, conducting a non-revenue flight from **{$\mathbf{TBD_7}$}** to **{$\mathbf{TBD_8}$}**

A. Flight OWS-7A is scheduled to depart **{$\mathbf{TBD_1}$}** at $\mathbf{T_1}$ hrs UTC to **{$\mathbf{TBD_2}$}**.

1. The EJR-145 has only recently been introduced to the OWS fleet, so the flight dispatcher retrieves baseline data for aircraft and crew capabilities from OWS Flight Dispatch System database. Data not meeting aircraft and crew capabilities (TBD) is flagged.

2. The performance data for the EJR-145 indicates that a cruising altitude of $\mathbf{H_1}$000 feet is optimum for the standard route and that a runway length of $\mathbf{X_1}$000 feet is required to land with the passenger load and full fuel required. The maintenance data for the aircraft contains a trouble ticket against the in-flight de-icing mechanism.

3. From the passenger manifest for OWS 7A and ERJ-145 data, the flight dispatcher calculates weight and balance for the flight and fuel burn. Calculations that are not in compliance with predetermined parameters such as landing weight are flagged.

4. The normal route $\mathbf{R_1}$ from **{$\mathbf{TBD_1}$}** to **{$\mathbf{TBD_2}$}** is the lesser great circle route that overflies *Special Use Airspace* (**SUA)**$_{1.}$ $\mathbf{SUA_1}$ has an upper limit of $\mathbf{H_2}$000 feet {$\mathbf{H_2 > H_1}$} but is normally inactive at the time that the flight dispatcher expects flight OWS 7A to be overflying the area.

5. Dispatcher requests aeronautical information updates (NOTAMs) for **{$\mathbf{TBD_2}$}**, **{$\mathbf{TBD_3}$}** and **{$\mathbf{TBD_4}$}**

6. The response to (5) is a digital NOTAM closing **{$\mathbf{TBD_3}$}** due to adverse weather.

7. The flight dispatcher requests the latest hourly observations (METAR) and Terminal Area Forecasts (TAF) for $\mathbf{R_1}$ plus alternate airports **{$\mathbf{TBD_3}$}** and **{$\mathbf{TBD_4}$}.**

8. The response to (7) indicates a current ceiling of 1500 feet and visibility of 2 miles (below precision approach minimums) at **{$\mathbf{TBD_3}$}** that are expected to continue for 8 hours. The latest hourly observation (METAR) for **{$\mathbf{TBD_4}$}** indicates visual meteorological conditions, - current ceiling 3000 feet and visibility 4 miles - with no worsening predicted in the next 8 hours.

9. The flight dispatcher calculates the safe fuel load $\mathbf{F_1}$ U.S. gallons as $\mathbf{F_2}$ gallons to reach **{$\mathbf{TBD_2}$}** +$\mathbf{F_3}$ gallons to shoot the approach at **{$\mathbf{TBD_2}$}** and continue to **{$\mathbf{TBD_4}$}** + $\mathbf{F_4}$ gallons reserve**.**

10. The dispatcher retrieves the airport data for **{TBD$_4$}** and notes that it has two runways with GPS approaches, the longer runway having 2 segments with a total length of **X$_3$** thousand feet (**X$_3$>X$_1$);** both segments are open.

11. The flight dispatcher now subscribes to a web services notification mechanism to receive any NOTAMs that will affect *the route of flight from* **{TBD$_1$}** to **{TBD$_2$}** within **K$_2$** km of the aircraft's position during the planned period of the flight. An SUA NOTAM is returned advising that due to a live firing practice **SUA$_1$** will become active at **T$_1$**+1 UTC for 6 hours.

12. The flight dispatcher estimates that OWS 7A will enter **SUA$_1$** while it is active, so he selects a new flight level for OWS 7a that puts it **X$_3$**000 feet above **SUA$_1$** and re-calculates the safe fuel load at take-off to be **F$_5$** gallons.

13. The flight dispatcher now subscribes to a web services notification mechanism to receive any METARS or SIGMETS that will affect the route of flight within **K$_3$** km of the aircraft's position during the planned period of the flight.

14. At **T$_1$**-1 UTC the flight dispatcher files the flight plan for OWS 7A and makes the flight-briefing package available for the pilot to download via web services.

15. 10 minutes after **T$_1$**-1 UTC the OWS Flight Dispatch System receives updated aeronautical information (a Digital NOTAM) for **{TBD$_3$}** from the web services notification mechanism. The NOTAM advises that **{TBD$_3$}** is closed due to bad weather. The NOTAM is stored pending update to OWS 7A and display on the dispatcher's workstation.

16. OWS-7A is delayed 2 hours and at **T$_1$**+1 UTC (two hours after the briefing package was prepared) the pilot enters the cockpit, contacts the dispatcher (by voice) and downloads the pre-flight briefing packages prepared by the flight dispatcher from a web services file server.

17. The dispatcher displays the updates pending for OWS 7A and advises the pilot that there are updates. (The update information is superimposed on a display of the route as a highlight at the affected location, which can be expanded to show the update in either text or graphic format.)

18. OWS 7A is a regularly scheduled flight with which the pilot is familiar, and the closeness of **{TBD$_4$}** to **{TBD$_3$}** concerns him. He requests any updates from the OWS Flight Dispatch System. [*The OWS Flight Dispatch System provides updated weather and aeronautical data via web service messages to EFBs. Only weather data that has changed significantly or NOTAMs that have been issued since the time that the flight-briefing package was filed are sent. Company policy states that data to the cockpit EFB*

will be filtered according to airport and weather parameters, reviewed by the dispatcher and forwarded to the cockpit as needed.]

19. A web service message containing the NOTAM on **{TBD$_3$}** is received and displayed on the OWS-7A EFB.

20. Shortly after this a convective SIGMET is issued for a 3000 km^2 area containing **{TBD$_4$}** and **{TBD$_3$}.** The SIGMET is displayed on the dispatcher's workstation superimposed on the route, indicating a generally north to south line of thunderstorms currently 20km west of **{TBD$_4$}** and moving NE at approximately 12 kts per hour and expected to clear the area within an hour. The dispatcher transmits the URL of this SIGMET in a web services message to the EFB.

21. The pilot retrieves the SIGMET using the URL provided to him and is concerned that **{TBD$_4$}** may still be below minimums while the aircraft is in the area, so he opens a connection to a web services weather server and requests a graphic view of the weather for the area along his projected approach to **{TBD$_4$}**.

22. After looking at the graphic weather image returned by the web services weather server the pilot confirms **{TBD$_4$}** to the flight dispatcher as his alternate airport.

23. The pilot subscribes to a web services notification mechanism to receive any NOTAMs on navigational aids, airports, runways or airspaces that will affect the route of flight within **K_2** km of the aircraft's position during the planned period of the flight. The pilot also subscribes to a web services notification mechanism to receive any METARS or SIGMETS that will affect an area at his flight level within **K_3** km of the aircraft's position during the planned period of the flight.

24. Within 10 seconds a lengthy *Flight Data Center* (FDC) NOTAM in text is returned on **{TBD$_4$}** notifying that GPS *Instrument Approach Procedures* (IAP) are temporarily unavailable. The pilot requests web services to provide a graphic format of the FDC NOTAM, which he displays on his EFB as an overlay on a map of his route. As an ILS IAP is available the pilot sees no problem with **{TBD$_4$}**.

25. The pilot and flight dispatcher jointly sign off on the flight by exchanging authenticated electronic signatures using a secure web services protocol.

26. The pilot waits for the *pre-departure clearance (PDC)* from air traffic control The PDC arrives in a web services message from the OWS AOC at **T_1**+3 UTC, and the pilot pushes back shortly afterwards.

27. At **T_1**+4 UTC, the dispatcher receives an alert for **{TBD$_4$}** indicating that the RVR for runway 7R/25L is OTS. OWS Flight Dispatch System displays the alert to the

dispatcher along with airport/facility data for **{TBD$_4$}**, showing that the parallel runway, 7L/25R, also has an RVR. **{TBD$_4$}** is currently reporting clear skies and unrestricted visibility, and is forecast to maintain those conditions for several hours. The dispatcher elects not to forward the alert to OWS-7B's cockpit EFB.

28. *Alternatively, the parallel runway is not available and the weather is below VFR minimums; the alert is displayed to the pilot and dispatcher; the pilot confirming to the dispatcher that he has received the same alert. (Scenario needs to be terminated if this option is taken)*

29. At 12:00 UTC, flight OWS 7A lands without incident at **{TBD$_4$}**. The pilot sends the time of arrival via web messaging to the OWS Flight Dispatch Center.

A OWS 7C has been chartered for a flight from **{TBD$_5$}** to **{TBD$_6$}** (in Canada) at 12:00 UTC on 12 Feb 2010. The customer calls OWS Flight Dispatch Service the night before and requests the departure time be moved up to 03:00 UTC. The weather is forecast to be below the pilot's personal minimums for the new ETA, so an alternate airport must be chosen. The pilot has elected not to fly through areas of 25% or higher probability of icing.

A.1	*Dispatcher requests weather and aeronautical information for flight plan route and altitude.*
A.2	*Dispatcher selects baseline data for aircraft and crew capabilities from OWS Flight Dispatch System database.*
A.3	*Dispatcher reviews draft flight plan, accepts proposed optimal route and altitude, and files flight plan. Dispatcher uploads weather and aeronautical data to pilot EFB.*
A.4	*Dispatcher obtains passenger manifest and using data for aircraft type PC12, calculates weight and balance for the flight and fuel burn. Calculations that are not in compliance with predetermined parameters such as landing weight are flagged. Dispatcher reviews data and uploads data to pilot EFB.*
A.5	*Dispatcher forwards an amended ETA to Canadian Customs.*

B At 08:00 UTC, the pilot of OWS 7D logs on to the OWS Flight Dispatch Center web portal to obtain a preflight briefing and file a flight plan for a flight from **{TBD$_7$}** to **{TBD$_8$}**

B.1	*Pilot enters draft flight plan data* **{TBD$_7$}-{TBD$_8$}** *and requests weather and aeronautical information for flight plan route and altitude.*
B.2	*Pilot selects baseline data for aircraft and crew capabilities from OWS Flight Dispatch System database.*
B.3	*OWS Flight Dispatch System shows textual and graphical display of weather and aeronautical information. Weather data not meeting aircraft and crew capabilities, including pilot's desire to avoid areas of moderate or greater turbulence, is flagged. Draft route and altitude plus optimal route and altitude based on aircraft and pilot capabilities are displayed.*

B.4	*Pilot reviews draft flight plan, accepts proposed optimal route and altitude, and files flight plan. Weather and aeronautical data uploads to pilot EFB.*
B.5	*Using data for BE58, pilot calculates weight and balance for the flight and fuel burn, and uploads data to pilot EFB.*
B.6	*Dispatcher receives alert regarding proposed departure OWS 7D.*

C At 5:00 UTC, when OWS 7C has been airborne for over 2 hours, the dispatcher receives an alert from the Web Notification Service that adverse weather is forecast to affect the route and/or the altitude of flight OWS-7C.

C.1	*OWS Flight Dispatch System makes a request to weather WFS to retrieve forecast adverse weather conditions along the flight route and based on altitude of flight.*
C.2	*The OWS Flight Dispatch System displays the weather information along with the forecast weather events. The display shows a strong weather system that will affect the flight route within the times specified.*

D The dispatcher calculates an amended route to **{TBD$_6$}** that will avoid the adverse weather, and sends the amended route to the EFB on OWS-7C. The pilot is alerted to the amendment, reviews and accepts the route and transfers the data to the flight management system (FMS).

D.1	*The OWS 7C EFB displays the original route and the amended route of flight, with the amended route highlighted.*

E At 09:00 UTC, the pilot of OWS 7D departs, and sends a text message to OWS Dispatch Center advising his actual time of departure. Dispatcher display updates proposed flight to departed flight.

F At 09:00 UTC, flight OWS 7C lands at **{TBD$_6$}**

F.1	*Time of arrival forwarded to Canadian Customs authorities.*

G At 14:00 UTC flight OWS 7D lands at **{TBD$_8$}**.

G.1	*Pilot sends his arrival time to OWS Flight Dispatch Center via web service message.*