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Request for Quotation (RFQ)

And

Call for Participation (CFP)

OGC Web Services Initiative - Phase 5 (OWS-5)

Annex B

OWS-5 Architecture

RFQ Issuance Date: May 11, 2007

Proposal Due Date: June 8, 2007

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1 Overview

The architectures presented in this Annex are based upon a collaborative effort between OGC Web Services 5 (OWS-5) Sponsors and OGC's IP Team. The architecture team used results from previous and ongoing OGC Interoperability Program initiatives, existing OGC discussion papers and specifications, OGC Technical Committee activities, and publicly available documentation from related standards initiatives (W3C and ISO) and elsewhere.

Section 2 provides an overview of the OWS-5 development threads.

Section 3 discusses the architectural approach and technical baseline for OWS-5.

Section 4 discusses the architectural approaches and issues for each of the OWS-5 development threads.

The OGC portal 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/resources/?page=glossary

2 OWS-5 Initiative Threads

The OGC is engaged in an Interoperability Program which is a global, hands-on and collaborative prototyping program designed for rapid development and delivery of proven candidate specifications into OGC's Specification Program which can then be formalized for public release. In OGC's Interoperability Initiatives, international technology developers and providers team together to solve specific geo-processing interoperability problems posed by the initiative's sponsoring organizations. OGC Interoperability Initiatives include test beds, pilot projects, interoperability experiments, and interoperability support services – all designed to encourage rapid development, testing, validation and adoption of open, consensus based standards specifications.

The policies and produces that define the OGC Interoperability Program are available here: http://www.opengeospatial.org/about/?page=ippp

In January of 2007, the OGC issued a call for sponsors for an OGC OWS-5 Interoperability initiative testbed activity to advance OGC's open framework for interoperability in the geospatial industry. Three meetings were conducted with potential OWS-5 sponsors to review the OGC technical baseline, discuss OWS-5 results, and identify OWS-5 requirements. Sponsors have expressed keen interest in advancing standards for sensor webs, semantics, CAD/GIS/BIM interoperability, mass market applications and geospatial processing. After analyzing the sponsors input, the OGC Interoperability Team recommended to the sponsors that the content of the OWS-5 initiative be organized around the following six threads:

1) Sensor Web Enablement (SWE)

2) Geo-Processing Workflow (GPW)

3) Information Communities and Semantics (ICS)

4) CAD/GIS/BIM

5) Agile Geography

6) Compliance and Interoperability Test and Evaluation (CITE)

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

2.1 Sensor Web Enablement (SWE)

The Sensor Web Enablement subtask will focus on continuing to refine the SWE specifications and applying the SWE specifications to solve realistic operation scenarios.

This work will result in enabling the federation of sensors, platforms and management infrastructure into a single sensor enterprise. This enterprise will enable the discovery and tasking of sensors as well as the delivery of sensor measurements regardless of sensor type and controlling organization.

Emphasis for SWE during this phase of the OWS project will be on:

- Leveraging results of OWS-4 to extend and integrate those specifications and implementations.
- Demonstrating SWE's ability to meet the geospatial needs of large enterprise system by integrating SWE into realistic enterprise workflow scenarios supported by Use Cases.
- Continuing previous test-bed efforts to integrate IEEE 1451 sensor into SWE
- Harmonizing SWE concepts and specifications with other OGC specifications and initiatives.
- Developing compliance test for SWE specification to facilitate adoption

In OWS-5, emphasis of interoperability engineering activities for the SWE thread will be on integration and demonstration of physical sensors and simulators within a realistic operating environment. In addition, progress is expected on enhancements to the SWE specifications as described in the "Future work" clauses of the respective baseline documents.

2.2 Geo-Processing Workflow (GPW)

The work of OGC Interoperability and Specification Programs has produced a significant body of knowledge and experience in designing, building and deploying Web Services. The full potential of OGC Web Services as an integration platform will be achieved when applications and business processes can be composed to perform complex interactions using a standard process integration approach. The OASIS Web Services Business Process Execution Language (WS-BPEL, commonly referred to as BPEL) offers a language to meet this need where business processes can be implemented via web services so that any cooperating entity can perform one or more steps in a process the same way.

The Geo-Processing Workflow (GPW) thread builds on work accomplished during several previous initiatives. Beginning with OWS-2, the Image Handling for Decision Support (IH4DS) thread extended the baseline of OWS service types with image processing services. In OWS-3 the Common Architecture thread continued this work by applying the services developed in OWS-2 to the SWE and GeoDSS environments. In OWS-4, a baseline approach for OWS Workflow using BPEL was established and demonstrated in several scenarios. Several processing services were defined as profiles of the Web Processing Service, e.g., Topology Quality Assessment Service, Model Output Processing Service.

The Geo-Processing Workflow (GPW) thread aims to develop and demonstrate interoperability among geo-processes through service chaining, workflow and web services, with emphasis on the Web Processing Service (WPS) and SOAP bindings. The results will be realized through valued-added enterprise scenarios that demonstrate the power of interoperability and service-oriented architectures. The OWS-5 GPW thread aims to integrate and enhance OGC web services specifications drawing on accomplishments of previous initiatives to meet these objectives.

The GPW thread in this testbed is organized into the following inter-related work areas:

- Service Chaining and Workflow
- SOAP/WSDL Bindings for OWS Services
- Web Processing Service Profiles
- Streaming of Imagery in OWS
- Access to and Processing of Predictive Models
- OWS Integrated Clients

2.3 Information Communities and Semantics (ICS)

The objective of this testbed is to focus on achieving practical results that are focused on process integration and 'right-sizing' of services to demonstrate the power of interoperability and service-oriented architectures using OGC Web Services.

In the ICS thread, tasks will focus on applying results from previous initiatives and experiments to develop new GML application schemas and information models for catalog search services.

To this end, the Information Communities and Semantics (ICS) thread in OWS-5 will perform tasks in the following areas:

- GML Application Schema Development
- UML-GML Application Schema tool
- CS/W ebRIM profile of ISO 19115

2.4 CAD/GIS/BIM (CGB)

The CGB activities in the OWS program are directed toward bridging the information models and workflows of the various communities involved with the representation of the built environment in three dimensions. Standards for interoperable exchange of information about buildings and standards for representing and exchanging information about cities at broad-scale are beginning to enable owners, administrators and toolmakers to make investments in developing assets based on these standards. Applications of integrated city models are emerging in the mass-market sphere, witness Google Earth and Microsoft Local Live. One can imagine the extension of these tools into the domains of location-based services to emergency preparedness and response. These applications will require the integration of semantically rich authoritative information that is likely to be created in a highly distributed fashion. This thread of OWS-5 focuses on developing a services-based architecture that will bring the necessary information together, and to make it accessible in a secure way.

2.5 Agile Geography

This testbed focuses on process integration and 'right-sizing' of services to demonstrate the power of interoperability and service-oriented architectures using OGC Web Services. The Agile Geography thread explores this goal through two distinct activities.

The first—GeoSynchronization and Sharing—extends the WFS Transactional architecture to target a federated environment comprised of loosely affiliated parties who desire to collaborate, in full or in part, on the maintenance of a shared geospatial data set.

The second activity explores the future of lightweight payloads of geospatial information on the Web, applying the concepts of links, bookmarks and Web pages to digital cartography and geospatial information management. Participants will explore the harmonization of KML and OWS Context document encodings and prototype client and server software that exploits these documents.

2.6 Compliance and Interoperability Test and Evaluation (CITE)

Validating compliance with an OGC specification means verifying that a software product has implemented the specification correctly by testing the software interface for response and behavior that is outlined in the specification. Verifying compliance to the standard is necessary in order to achieve interoperability. As a result, geospatial application vendors desire to provide their potential costumers a means to verify adherence to OGC standards as a measurable discriminator for the interoperability of software products. Similarly, users desire assurance that acquired software components will interoperate with their existing investments in OGC-compliant technology. The Conformance and Interoperability Test and Evaluation (CITE) thread is intended to provide the geospatial industry (consumers and vendors) a methodology and tools that will test compliance with OGC web services.

The OGC Interoperability Program and the OGC Specification Program have achieved a great deal of momentum as a result of the multiple OGC web service specifications that have recently been published. Key consumers in the geospatial industry are modernizing their enterprises based on the applicability and interoperability of OGC web services. The major geospatial industry consumers require verifiable proof of compliance with OGC specifications in order to reach the desirable outcome of interoperability. Furthermore, as the OGC technology stack has matured, a group of interfaces has emerged that represents a baseline of technology needed to implement a fully interoperable, end-to-end *spatial data infrastructure*. The OWS-4 CITE thread made significant progress towards having a complete suite of compliance tests for this baseline of interfaces. In OWS-5, transitioning the WCS 1.0 compliance tests to the new, open source TEAM Engine will complete this work.

A major focus of OWS-5 is enterprise workflow. To that end, the CITE thread will develop SOAP and WSDL compliance test suites and reference implementations for four specifications, WFS, WMS, WCS and CS/W. A reference implementation is an open source, fully functional implementation of a specification in reference to which other implementations can be evaluated. The OGC provides open source reference implementations to ensure maximum transparency of its specifications for both vendors and customers.

3 OWS-5 Baseline

3.1 OpenGIS® Reference Model

Relevant Specifications: OpenGIS® Reference Model version 0.1.3

(http://portal.opengeospatial.org/files/?artifact_id=3836)

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 will be revised on a regular basis to continually and accurately reflect the ongoing work of the Consortium. It is encouraged that respondents to this RFQ 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). This Annex of the OWS-5 RFQ will deal with the upper four views; Enterprise, Information, Computational, and Engineering as shown in the figure below. Each thread of the initiative will be described in the annex using any or all of these four views.

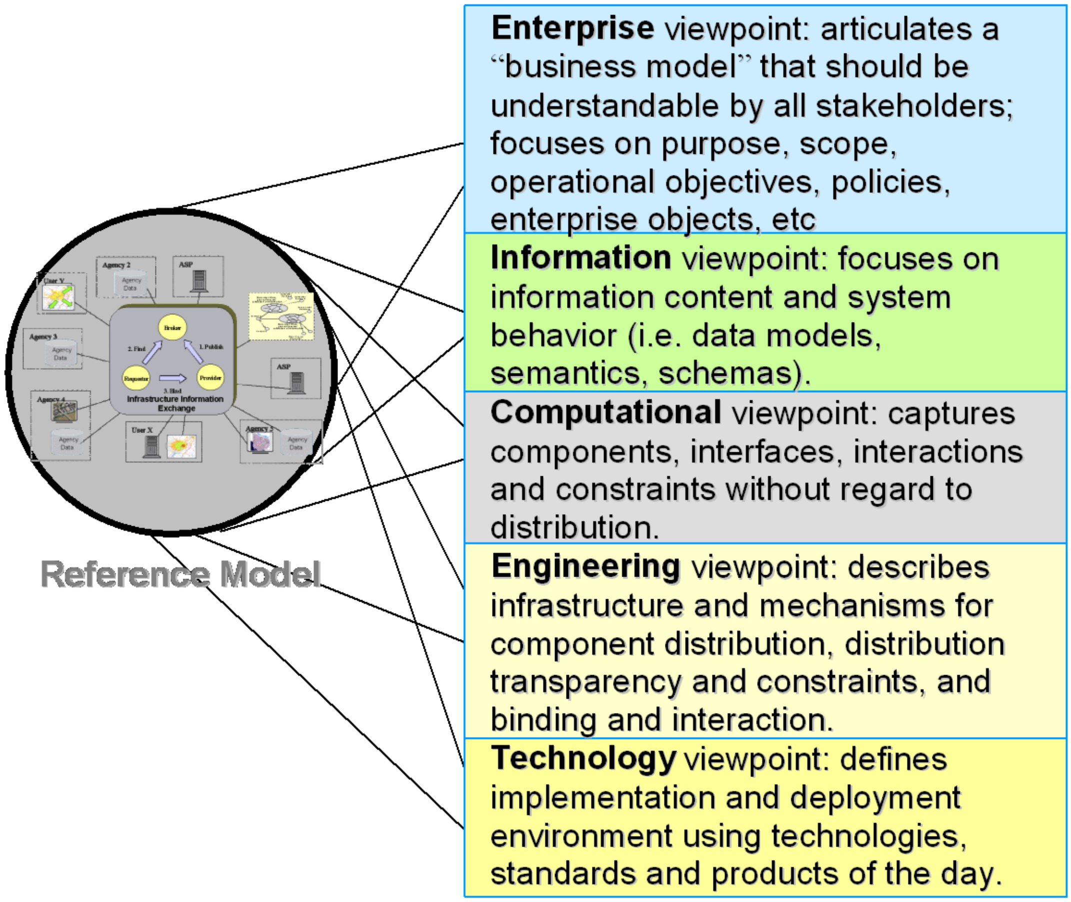


Figure 1: ORM Reference Model

3.2 OGC Standards Baseline

The OGC Standards Baseline, at any point in time, is the set of all Adopted Specifications plus all other technical documents that have been made available to the public by the OGC Technical and Planning Committees. The Standards Baseline all member approved implementation/abstract specifications and best practices documents. These specifications and other documents are freely available to the public at this website: http://www.opengeospatial.org/specs/?page=baseline

With the exception of the CITE thread, OWS-5 will use GML version 3.2.1 which is available as OGC Document 07-036. It is anticipated that the next version of GML that the OGC Specification Program will approve will be 3.2.1, which is anticipated to be equivalent to the ISO International Standard for GML.

Several documents were approved for public release at the recent OGC TC/PC meeting in April 2007 and are being processed for public release. These documents will become available over the next few weeks. If a specific document is needed by a proposer and it has not yet been published to the public link above, contact OGC (techdesk@opengeospatial.org).

The following table lists the approved OGC Specifications that are relevant to OWS-5. In some cases OWS-5 specifies a version which is different from the approved specifications in this table, e.g., GML 3.2.1.

Approved OGC Specifications Related to OWS-5

Title	Version	Document #	Date
IMPLEMENTATION SPECIFICATIONS			
Catalog Service	2.0.2	07-006r1	2/23/2007
Web Map Service (WMS)	1.3.0	04-024	8/2/2004
Web Coverage Service (WCS)	1.1	06-083r8	10/17/2006
Web Map Context (WMC)	1.1	05-005	1/19/2005
Geography Markup Language (GML)	3.1.1	02-023r4	1/29/2003
Styled Layer Descriptor (SLD)	1	02-070	8/19/2002
Web Feature Service (WFS)	1.1	04-094	5/03/2005
Filter Encoding	1.1	04-095	5/03/2005

3.3 OGC Request For Comment Baseline

The OGC Request for Comment (RFC) process is the procedure for OGC Specification Program to adopt an Implementation Specification. RFC documents are one step prior to adoption. RFC documents are to be used in lieu of prior OGC Discussion Papers on the same topics. The RFC documents have been made available at this website: http://www.opengeospatial.org/standards/requests.

Requests for Comment Related to OWS-5

Title	Version	Document #	Date
OpenGIS® Sensor Planning Service (SPS): Request for Public Comments	0.0.30	05-089r	2005-09-28
OpenGIS® Transducer Markup Language (TML): Request for Public Comments	1.0.0	06-010r2	2006-03-03
OpenGIS® Sensor Observation Service (SOS): Request for Public Comments	0.1.5	06-009r1	2006-02-13
OpenGIS® Sensor Model Language (SensorML): Request for Public Comments	1.0	05-086r2	2006-02-01

3.4 OGC Best Practice 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.

Title	Version	Document #	Date
(BXML) Encoding Specification	0.0.8	03-002r9	2006-01-18

Title	Version	Document #	Date
Definition identifier URNs in OGC namespace	1.1.0	06-023r1	2006-08-08
FGDC CSDGM Application Profile for CSW 2.0	0.0.12	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 PIDF-LO Geometry Shape Application Schema for use in the IETF	0.0.9	06-142	2007-01-25
ISO19115/ISO19119 Application Profile for CSW 2.0 (CAT2 AP ISO19115/19)	0.9.3	04-038r2	2005-04-27
Observations and Measurements	0.14.7	05-087r4	2006-10-11
OpenGIS® Geography Markup Language (GML) Encoding Specification	3.1.1	03-105r1	2004-04-19
OpenGIS® web services architecture description	0.1.0	05-042r2	2005-11-21
Specification best practices	1.0.0	06-135r1	2007-01-29
Units of Measure Recommendation	1.0	02-007r4	2002-08-19
Web Coverage Processing Service (WCPS)	0.0.3	06-035r1	2006-07-26
Web Notification Service	0.0.9	06-095	2007-01-25

The following OGC Best Practice Document was approved for Public Release at the last Technical and Planning Committees in April 2007 pending minor revisions. To request a copy of this document, please email the OGC Technology Desk (techdesk@opengeospatial.org).

Title	Version	Document #	Date
KML Reference Document	0.0.9	07-039	3007-03-07

3.5 OGC Discussion Papers Baseline

OGC Discussion Papers 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. These discussion papers have been made available at this website: http://www.opengeospatial.org/standards/dp.

Discussion Papers Related to OWS-5

Title	Version	Document #	Date
A URN namespace for the Open Geospatial Consortium (OGC)	2	06-166	2007-01-30
City Geography Markup Language	0.3.0	06-057r1	8/18/2006
Compliance Test Language (CTL) Discussion Paper	0.4.0	06-126	2006-10-18

Title	Version	Document #	Date
Geographic information - Rights expression language for geographic information - Part xx: GeoREL	0.9.0	06-173r2	2007-01-25
Geospatial Portal Reference Architecture	0.2	04-039	9/22/2004
Geospatial Semantic Web Interoperability Experiment Report	0.5.0	06-002r1	8/21/2006
GeoXACML, a spatial extension to XACML	0.0.1	05-036	2005-06-17
GML Performance Investigations by CubeWerx	1.0.0	05-050	2006-05-02
OGC Web Services (OWS) 3 UGAS Tool	0.0.3	05-118	2006-04-28
OGC Web Services SOAP Experiment Report	0.8	03-014	2003-01-15
OpenGIS® Catalogue Services - ebRIM (ISO/TS 15000-3) profile of CSW	1.0.0	05-025r3	10/24/2006
OpenGIS® Sensor Web Enablement Architecture Document	1.0	06-021r1	3/27/2006
OpenGIS GML 3.2 image geopositioning metadata application schema	0.0.0	06-055r1	2006-07-12
OpenGIS Image Geopostioning Service	0.0.0	06-054r1	2006-07-12
OWS-3 Imagery Workflow Experiments: Enhanced Service Infrastructure Technology Architecture and Standards in the OWS-3 Testbed	0.9	05-140	2006-03-30
OWS1.2 Image Handling Design	0.5	04-051	2004-09-26
OWS1.2 Image Handling Requirements	0.1.4	04-052	2004-09-26
OWS 2 Common Architecture: WSDL SOAP UDDI	1.0	04-060r1	2005-02-17
OWS 3 GML Investigations - Performance Experiment by Galdos Systems	0.0.4	05-101	2006-04-19
OWS3 GML Topology Investigation	0.0.5	05-102r1	2006-05-09
OWS Integrated Client (GeoDSS Client)	0.0.3	05-116	2007-03-08
Schema Maintenance and Tailoring	0.0.7	05-117	2006-05-02
Sensor Alert Service	0.2.0	06-028	2006-04-05
Styled Layer Descriptor Profile of the Web Map Service Implementation Specification	1.1	05-078	2006-04-21
Symbology Management	0.2.1	05-112	2006-04-19
Temporal Standard Recommendations	0.0.9	06-022r1	2006-04-21
WCS Change Request: Support for WSDL & SOAP	0.1.0	04-049r1	2005-04-22
WMS Part 2: XML for Requests using HTTP Post	0.0.3	02-017r1	2002-08-24
XML for Image and map Annotation	0.4	01-019	2001-02-06

The following OGC Discussion Papers were approved at the last Technical and Planning Committees in April 2007. These documents are awaiting minor revisions and have not yet been posted to the public site. To request a copy of any of these documents, please email the OGC Technology Desk (techdesk@opengeospatial.org).

Recently Approved OGC Discussion Papers Relevant to OWS-5

Title	Version	Document #	Date
Feature Styling IPR	0.4.1	06-140	2006-12-07
FramImage geopositioning metadata GML 3.2 application schema	0.0.0	07-032	2007-03-20
GeoDRM Engineering Viewpoint and supporting Architecture (OWS-4 GeoDRM Interoperability Report)	1.0.0	06-184	2007-02-09
GEOINT Structure Implementation Profile Schema Processing	0.4	07-028	2007-03-25
GML Encoding of Discrete Coverages - (interleaved pattern)	0.2.0	06-188r1	2007-04-04
GML Implementation of some simple solids, planes and lines	0.1.0	07-001	2007-01-15
Local MSD Implementation Profile for GML 3.2.1	0.5	07-027	2007-03-25
OGC™ Cataloguing of ISO Metadata (CIM) using the ebRIM profile of CS-W	0.1.0	07-038	2007-03-22
OGC Web Services Architecture for CAD GIS BIM	1.0	07-023	2007-02-11
OWS-4 CSW ebRIM Modeling Guidelines IPR	0.0.5	06-155	2007-03-12
OWS-4 IPR for WCS-T		06-098	2006-11-16
OWS-4 IPR for WCS Support for JPEG 2000		06-128	2006-12-11
OWS-4 GeoDSS Mass Market IPR	0.0.1	07-004	2007-01-22
OWS4 Topology Quality Assessment IPR	0.2	07-007r1	2007-02-12
OWS4 WFS/Oracle Temporal Investigation	0.0.1	06-154	2006-12-21
OWS-4 Workflow IPR	1.0.0	06-187	2007-01-22
OWS-4 WPS IPR	1.0.1	06-182r1	2007-01-05
SPS Application Profile for EO Sensors	0.9.3	07-018	2007-03-09
Trusted Geo Services IPR	1.0.0	06-107	2007-01-22

3.6 Non-OGC Standards Related to OWS-5

Non-Open Geospatial Consortium Standards Related to OWS-5

Name	Specification	Description
WSDL	Web Services Description Language v 1.2 W3C Working Draft	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	Simple Object Access Protocol (SOAP) is a protocol specification from W3C for exchange of information in a decentralized, distributed environment.
BPEL4WS	OASIS Web Services Process Execution Language	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.
OWL	OWL Web Ontology Language Overview – W3C Recommendation 10 Feb 2004	The OWL Web Ontology Language is designed for use by applications that need to process the content of information instead of just presenting information to humans.

4 OWS-5 Architecture

4.1 Sensor Web Enablement (SWE)

The Sensor Web Enablement (SWE) architecture was designed to enable the creation of 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 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.

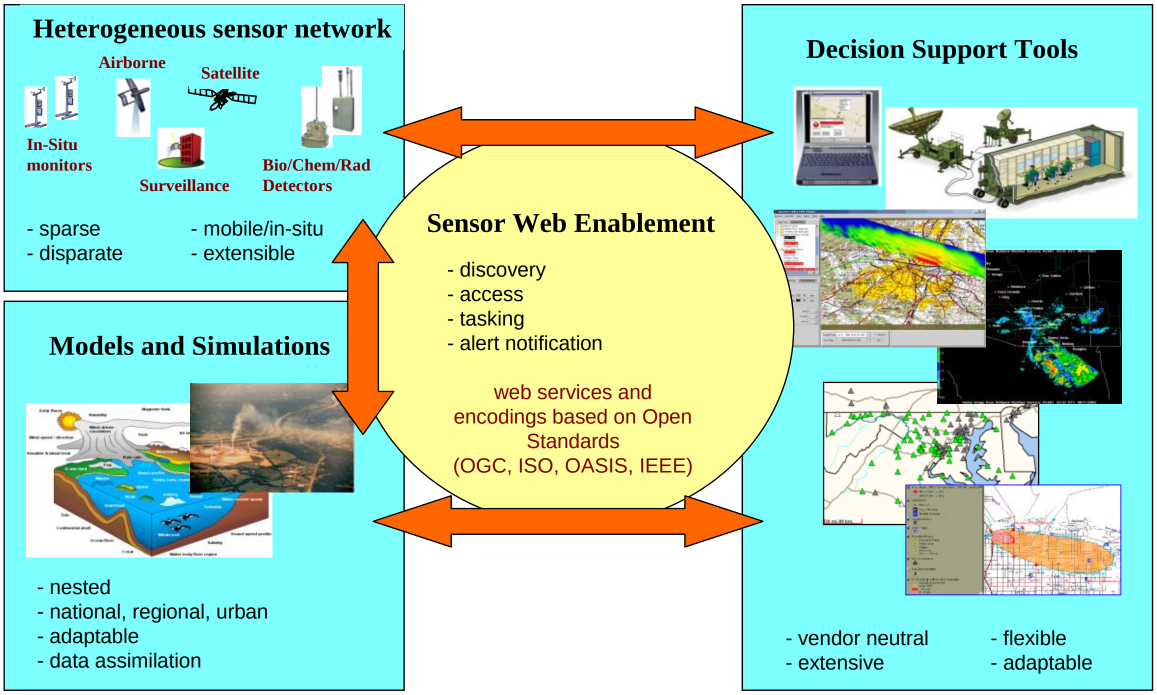


Figure 2: The role of SWE

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.

It is expected that the following specifications will be used in this initiative. An explanation of these specifications can be found in the SWE Computational Viewpoint Section

- SensorML (OGC 07-000) –v1.0 Implementation Specification
- TransducerML (OGC 06-010r6) –v1.0 Implementation Specification
- Sensor Observation Service (OGC 06-009r5) – v1.0 Implementation Specification
- Sensor Planning Service (OGC 07-014) –v1.0 Implementation Specification
- Observations & Measurement (O&M) (OGC 05-087r4) –Best Practices
- Sensor Alert Service (OGC 06-028r2) – Best Practices Paper
- Web Notification Service (OGC 06-095) – Best Practices Paper

4.1.1 SWE Scope

The OGC Sensor Web Enablement framework has achieved a reasonable degree of maturity over past six OWS interoperability initiatives. OWS-5 will focus on integrating the SWE interfaces and encodings into cross-thread scenarios and workflows to demonstrate the ability of SWE specifications to support operational needs.

Emphasis for SWE during this phase of the OWS test-bed will be on:

- Leveraging results of OWS-4 to refine extend and integrate those specifications and implementations.
- Harmonizing SWE concepts and specifications with other OGC specifications and initiatives.
- Demonstrating support for realistic operational scenarios
- Further pervious work of integrating IEEE1451/NCAP sensor into SWE.
- Incorporating SWE into enterprise workflows

4.1.1.1 IEEE1451 Sensor Integration

In OWS-4, work was done to enable a “plug-and-play” sensor framework by integrating IEEE 1451 enabled sensors into a SWE based, web services environment. In OWS-5 an emphasis will be placed on developing a Smart Transducer Web Services which is a concept associated with achieving interoperability by integrating IEEE1451/NCAP enabled sensors into a larger enterprise system using SOA and SWE. This work will primarily focus on extending pervious IEEE-1451, SWE integration. A WSDL, or similar technology, will be used to describe the Smart Transducer Web Services and facilitate integration into enterprise systems and workflows. The figure (Figure 3) below illustrates a proposed solution to this task.

Results of this activity are anticipated to be change requests to the related baseline specifications, specification profiles for specific classes or applications of sensors, and worked examples for use in demonstrations of realistic operational scenarios.

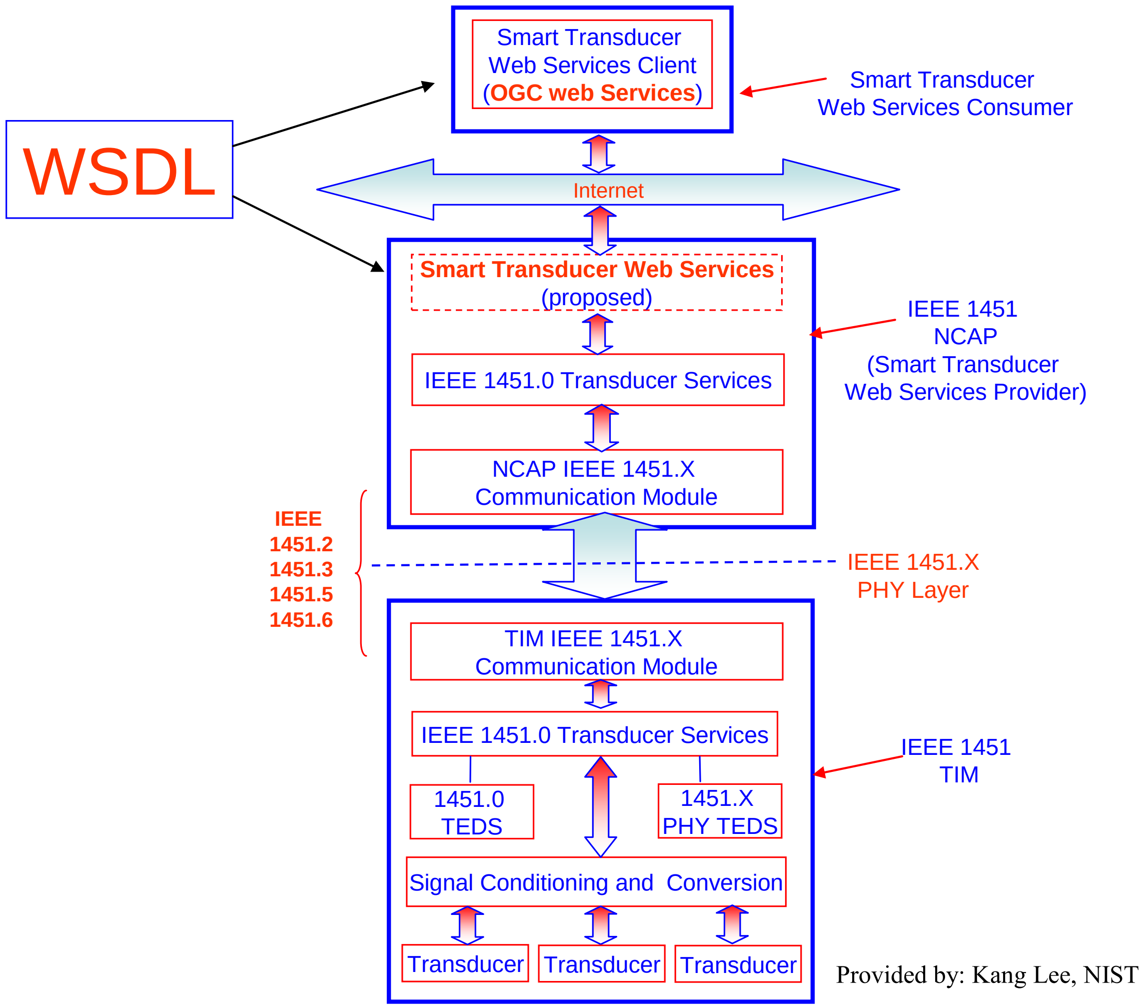


Figure 3: Proposed Solution to Smart Transducer Web Services Task

4.1.1.2 Incorporation of SWE into GPW

An objective of the OWS-5 SWE thread is to integrate SWE capabilities into larger workflows to develop a system capable of meeting realistic operational needs. This capability will be based on the service chaining and workflows developed in the Geospatial Workflow Processing (GPW) thread of OWS-4. Developers of SWE components are expected to work with the OWS-5 Common Architecture and GPW teams to ensure that an integrated sensor observation processing value-chain can be demonstrated.

There are three activities associated with this task. The first is to develop a workflow that will be driven by GeoReferenceable imagery provided by a SOS. GeoReferenceable imagery is unprocessed imagery which has not been gridded or geolocated. The primary objective of this activity is to establishment of a standardized means to allow the user to interactively access a subset pixels from a coverage service stored in the compressed domain (JPEG2000) and preserve the image relationship with the associated 'sensor model' parameters such that precise geopositioning capabilities can be realized in a dynamic, interactive, networked environment. NGA requires two workflows for testing this capability. The first primary workflow does not require geopositioning of the imagery within OWS-5 but rather requires sensor and image information be retained and processed through the workflow so that image geopositioning is possible at a later time. This workflow exercises the time sensitive response to imagery requirements. The primary purpose of the second workflow is the ability to implement a geopositioning service as part of a web based capability. This workflow does not require further processing of the imagery after incorporation in a Web Coverage Service.

1) NGA requires the evaluation of JPEG 2000 Interactive Protocol (JPIP) to support time sensitive access to “georeferenceable” imagery. NGA requires interactive access to huge, non-rectified images (coverages) with the requirement to preserve the relationship of the image/coverage pixel coordinate index with the associated sensor parameters, adjustable parameters and error-propagation data so that the client can use whatever physical sensor model or Rapid Positioning Capability positioning tool available to the client to do precise geopositioning using the pixels interactively pulled from the server. Phase - 1
   i. Output from a Sensor Observation Service must include a Georeferenceable full image with functional fit parameters transferred to a Web Coverage Service
   ii. Output from the WCS-T must be a georeferenceable, clipped section of the image defining an area of interest with functional fit parameters capable of tying the location of the clip back to the position on the full image

2) NGA requires the implementation of an Image Geopositioning Service as part of a network-accessible production workflow. This would require that the coverage service, the JPIP protocol service, the geopositioning service and the client would need to be 'logically' in sync with the interactive transfer of pixels. Phase - 1
   i. Output from a Sensor Observation Service must include a Georeferenceable full image with functional fit parameters transferred to a Web Processing Service (Image Geopositioning Service-IGS)
   ii. Input to the IGS will include Terrain Data, sensor model/RPC, and the full image
   iii. Output from the IGS will be a geo-rectified image encoded in GMLJP2 for input into the JPIP enabled WCS

This effort will be facilitated by a JPIP enabled SOS that provides both TransducerML and JPIP encoding streaming responses. The SOS must also provide a SensorML instance which includes the functional fit parameters for the imagery. The JPIP approach used for WCS from OWS-4 (WCS JPIP CR - OGC Doc 06-128) should be used as a reference for this task. A result of this effort should include an evaluation of the further generalization of WCS to support thematic subsetting, irregular (non-gridded) spatio/temporal distributions, and sub/super-sampling on any or all axes, as it relates to SOS.

The second GPW related activity involves providing sensor measurements via a SOS that will be used within a workflow. The sensor data provided via the SOS will have one or more processes or transformations applied to it and the result will be features which were derived from the initial observations. These features will then be made available via a WFS. The observations will be provided by IEEE-1451, or similar, sensors that were discovered using a sensor web registry. URNs will be used to define specific metadata parameters and the OGC hosted URN resolver should be used to provide concrete artifacts referenced by a URN. This is a cross thread effort and the specific details of data to be provided will be driven by the GPW thread. The figure (Figure 4) below provides an illustration of this workflow.

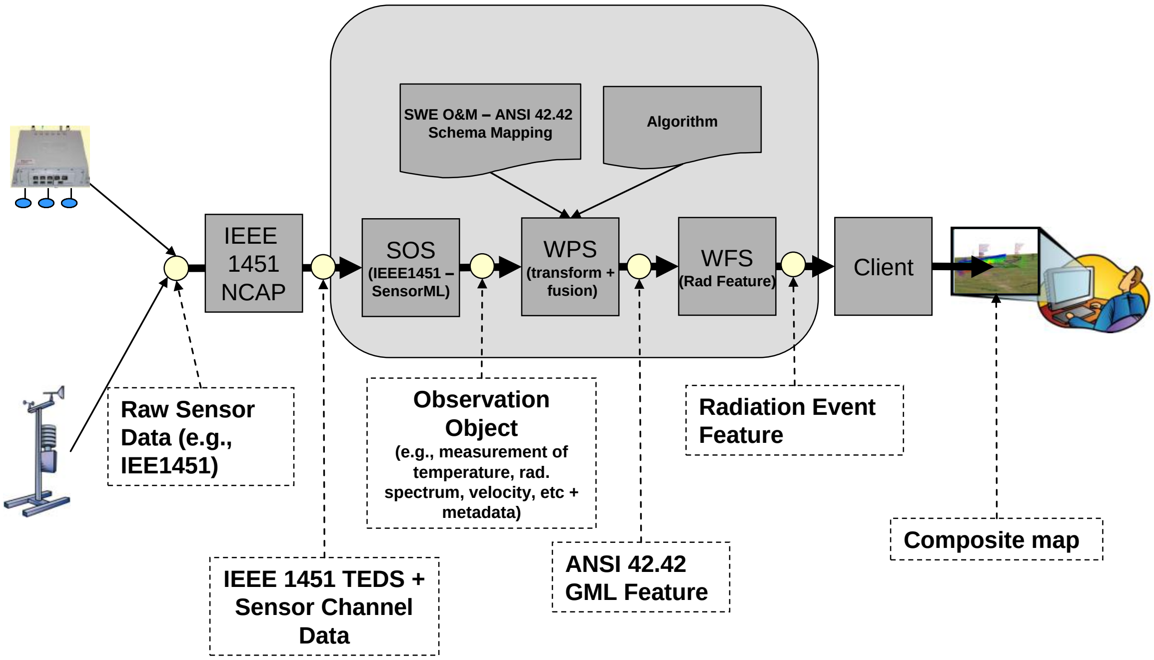


Figure 4: Workflow

The NASA EO workflow scenario is also a cross thread effort that requires interaction with the SWE thread. In this scenario the results of a GPW will be used to task a sensor using SPS. Image data, possibly provided via a SOS, will be process though a GPW and the result of this processing will identify areas over which additional data collection is required. This collection will be requested via SPS and the resulting data will be accessed via SOS. This scenario will address the need to make the SWE specifications suitable for consumption by the mass market. The scenario will include alternative "push" notification technologies which could support a generalized SWE publish/subscribe mechanism as a possible alternative to the existing OGC WNS. Current OGC information models like O&M and SensorML are highly suitable for expert technical use, but much less so for casual users. In an effort to make these models more accessible to a large community, this scenario will apply GeoRSS, KML and other mass market technologies.

As workflows consisting of WPS, WCTS and other web services are used to process data provided by sensor observations it is then necessary to store these results using a means which facilitates discovery and retrieval by end users. A transactional WCS will provide an interface that supports the creation of coverages based on sensor data processed using a common set of parameters. Users can then easily discover and access this data using the WCS interface. Populating a WCS with the workflow results also ensures that workflows will only be executed if the necessary data is not available via the WCS. The primary use case will involve having a user request subsets of image data. If the desired data does not already exist in the WCS, then the workflow will access an SOS to retrieve non-georeference image and metadata. The workflow will then use the functional fit parameters in the metadata to georeference the image segment and transact the result to a WCS from which the user will retrieve the data. It may be necessary to add enhancement to the WCS specification to facilitate subsetting based on irregular (non-gridded) spatio/temporal distributions and sub/super-sampling on any or all axes as is provided by SOS.

4.1.1.3 SWE Integration into existing systems

The SWE specifications have reached a level of maturity that makes them suitable for use in within larger systems. Before the SWE specification may be widely adopted by the user community, it is necessary to develop compliance testing. This need is most prevalent in defense and intelligence organization which require compliance tests and reference implementations for acceptance. OWS-5 will produce compliance test and reference implementation for SPS, SOS, SensorML and TransducerML. The development of theses compliance test will primarily fall under the responsibility of the CITE thread. The development of reference implementations and integration of SWE into existing operational systems will likely be associated with cross thread integration efforts.

4.1.1.4 TPPU using SWE Specifications

To facilitate wider adoption of the SWE specifications it is necessary to produce a report which identifies an implementation approach for applying OGC standards to 'standardize' the tactical, near-real-time, imagery Tasking, Posting, Processing, and Utilization (TPPU) objectives of the DCGS architecture. The result of this effort will be a technical report that clearly lays out several viable approaches for the application of OGC standards to support near-real-time remote sensing applications for both still and motion imagery, to include electro-optical, spectral, SAR, and LIDAR sensors. Of particular interest are sensor planning/tasking services, sensor observation services, sensor discovery services, streaming data (and metadata flow), TransducerML, SensorML, etc. The report should provide a summary of technical and operational pros/cons for the proposed approaches, and an expert assessment of technical risk (i.e. how mature/tried are the standards in the proposed approaches). A result of this document will be the nomination of experiments for upcoming OWS efforts based on the risk assessment of the report.

4.1.2 SWE Requirements

1) Refine the integration of IEEE-1451 sensors into SWE
a) Apply SPS, SAS and SOS to develop a Smart Transducer Web Services which will reside within a IEEE-1451 NCAP
b) Use of TML, SensorML and O&M schema for generation, access and exploitation of IEEE-1451 enabled sensors
c) Identify and document enhancements for the SOS
d) Identify and document enhancements for the SPS
2) Utilize SWE within workflows
a) Identify and model the business processes and information flows needed to manage and implement sensor related information and workflows, specifically: i) The model shall scale to support large-area, multi-sensor and multi-agency sensor networks. ii) The model shall accommodate the use-cases documented in the SWE Enterprise Viewpoint and Appendix C of this document.
b) Refine and extend the SWE Information Model and schemas needed to implement the business processes and information flows
c) Develop a SOS which provides georeferenceable JPIP imagery and associated image metadata as SensorML
d) Provide a SOS that will support a measurement (SOS) to feature (WFS) workflow using IEEE 1451 sensors
e) Identify and document enhancements for SOS
f) Identify and document enhancements for SPS
g) Identify and document enhancements for WCS-T

Table 1 – SWE Requirements

4.1.3 SWE Deliverables

The following Interoperability Program Reports (IPRs) will be developed in the SWE thread and submitted to the OGC Specification Program at the completion of the OWS-5 Testbed.

1)	GeoReferenceable Imagery IPR (SOS/WPS/WCS)
2)	SWE Profile for TPPU - IPR describing how to apply SWE and other OWS specifications to facilitate the NRT application of EO, SAR and LIDAR and associated metadata workflow
3)	SOS Change Request IPR - describes changes needed to SOS as a Change Request. Must include updates to XML Schema, interaction diagrams and documented example requests and responses showing support for accessing and transacting observations of sensors systems supporting JPIP and IEEE-1451/NCAP.
4)	Mass Market/EO SWE Interfaces IPR. This IPR will describe how technologies such as GeoRSS, KML and others can be used to support SWE interfaces.
5)	SWE Change Requests IPR. This IPR will reflect all other SWE related enhancements and modifications identified during OWS-5.
6)	WCS Sub-setting IPR. This IPR describes enchantments necessary to enable WCS to provide a sub-setting capability similar to SOS.

Implementations of the following services, tools and data instances will be developed in this OWS-5 thread, tested in Technology Integration Experiments (TIEs) and invoked for cross-thread scenarios for OWS-5 demonstration events:

1)	SOS - Georeferenceable Image - a SOS implementation that ingests and serves JPIP image data. This SOS will also be responsible for serving metadata including functional fit parameters as SensorML to facilitate georeferencing.
2)	SPS for managing imaging resource for airborne (UAV) and spaceborne sensors. This SPS will be part of a larger workflow.
3)	Mass Market/EO SWE Implementations to support the application of technologies such as GeoRSS, KML and others to SWE interfaces.
4)	Provide a WCS-T which supports georeferenceable image subsetting. This implementation will serve GMLJP2 encoded Elevation Surface Model data (gridded coverage) based on the GML NAS draft 2.0.
5)	SOS for IEEE-1451 - a SOS implementation that ingests and serves data provided by an IEEE-1451 compliant sensor. This service will interoperate with the IEEE-1451/NCAP Smart Transducer Web Services environment and will support the observations to features workflow
6)	SWE Client – Provide a SWE client that can interact with the SWE implementations associated with the test-bed. This client will support SOS and SPS interface at a minimum.

4.1.4 SWE Enterprise Viewpoint

The Sensor Web Enablement thread will apply and mature the existing set of SWE specifications to enable the federation of sensors, platforms and management infrastructure into a sensor enterprise. A SWE enterprise will enable the discovery and tasking of sensors as well as the delivery of sensor observations regardless of sensor type and controlling organization. SWE brings geospatial web services interoperability to the diverse plug-and-play sensor hardware environment. The ultimate vision is of a sensor market place where users can identify, evaluate, select and request a sensor collection regardless of sensor type, platform or owner.

For more detailed information regarding SWE Viewpoints, reference the Sensor Web Enablement Architecture Discussion Paper (OGC 06-021r1).

4.1.4.1 SWE Use Cases

4.1.4.1.1 Use Case #1: Smart Transducer Web Services

<table>
<tr><td>Use Case Identifier: SWE #1</td><td colspan="3">Use Case Name: Smart Transducer Web Services</td></tr>
<tr><td colspan="3">Use Case Domain: OWS-5 SWE IEEE-1451</td><td>Status: Under development. Draft /12/17</td></tr>
<tr><td colspan="4">Use Case Description: This use case describes the basic discovery, tasking, notification and access of sensor data. It provides an operational context in which the more detailed use cases will operate.</td></tr>
<tr><td colspan="2">Actors (Initiators): User of sensor data</td><td colspan="2">Actors (Receivers) Same as initiator</td></tr>
<tr><td colspan="2">Pre-Conditions:
- User requires transducer data.
- User has authorization to request the collection of the needed data.</td><td colspan="2">Post-Conditions:
Sensor has been collected, processed and is provided to the user for exploitation.</td></tr>
<tr><td colspan="4">System Components
- CS-W: Catalog Service Web Profile
- SPS: Sensor Planning Service
- Sensor system: the collection of instruments that detect phenomena and generate the metadata associated with the readings as well as the underlying network and application infrastructure
- Data Server: A web service that stores and disseminates data, SOS
- Notification Service: Informs the user of events related to the requested automated processing</td></tr>
<tr><td colspan="4">Basic Course of Action:
1. User queries a CS-W to determine if needed data/sensor is available (Data discovery use case for)
2. Data is not available, but necessary sensor is available
3. Sensor is tasked
4. (Optional) User requests collection status from SPS or CS-W
Collection status provided to user through SPS response or user is notified
5. Collection delivered to a Data Server via SOS-T
6. User notified of collection status and access instructions through notification service
7. User accesses collection and associated metadata.</td></tr>
</table>

4.1.4.1.2 Use Case #2: JPIP Workflow

<table>
<tr><td>Use Case Identifier: SWE #2</td><td colspan="2">Use Case Name: JPIP Workflow</td></tr>
<tr><td colspan="2">Use Case Domain: OWS-5 SWE</td><td>Status: Under development. Draft 4/3/07</td></tr>
<tr><td colspan="3">Use Case Description: This use case describes the basic discovery, tasking, notification and access of sensor data. It provides an operational context in which the more detailed use cases will operate.</td></tr>
<tr><td colspan="2">Actors (Initiators): User of imagery data</td><td>Actors (Receivers) Same as initiator</td></tr>
<tr><td colspan="2">Pre-Conditions:
- User requires imagery.
- User has authorization to request the collection of the needed imagery.</td><td>Post-Conditions:
Imagery has been collected, processed and is provided to the user for exploitation.</td></tr>
<tr><td colspan="3">System Components
- CS-W: Catalog Service Web Profile
- SPS: Sensor Planning Service
- MCS: Mission Control System – manages the operation of the platform and sensor package
- Platform: the vehicle that the sensor package is mounted on
- Sensor Package: the collection of instruments that detect phenomena and generate the metadata associated with the readings
- Data Server: A web service that stores and disseminates data. Includes the WCS and SOS
- Notification Service: Informs the user of events related to the requested automated processing</td></tr>
<tr><td colspan="3">Basic Course of Action:
1. User queries a CS-W to determine if needed imagery is available (Data discovery use case for)
2. Imagery is not available
3. Airborne Collection is tasked
4. (Optional) User requests collection status from SPS or CS-W
Collection status provided to user through SPS response or user is notified
5. (Optional) User modifies tasking for sensor and platform
6. Collection status provided to user through notification service
7. Collection delivered to a Data Server
8. User notified of collection status and access instructions through notification service</td></tr>
</table>

9. User accesses collection. via SOS 10. User accesses functional fit parameters via SOS 11. Downstream processing occurs to georeference a portion of the image as needed.

4.1.4.1.3 Use Case #3: EO-1 Wildfire

Use Case Identifier: SWE #3	Use Case Name: EO-1 Wildfire Scenario
Use Case Domain: OWS-5 SWE	Status: Under development. Draft 4/12
Use Case Description: This use case describes the basic discovery, tasking, notification and access of sensor data. It provides actions in which workflow processing occurs.	
Actors (Initiators): User of imagery data	Actors (Receivers) Same as initiator
Pre-Conditions: - User requires imagery. - User has authorization to request the collection of the needed imagery.	Post-Conditions: Imagery has been collected, processed and is provided to the user for exploitation.
System Components - CS-W: Catalog Service Web Profile - SPS: Sensor Planning Service - MCS: Mission Control System – manages the operation of the platform and sensor package - Platform: the vehicle that the sensor package is mounted on - Sensor Package: the collection of instruments that detect phenomena and generate the metadata associated with the readings - Data Server: A web service that stores and disseminates data. Includes the WCS and SOS - Notification Service: Informs the user of events related to the requested automated processing	
Basic Course of Action: 1. Prior processing will identify regions of interest. 2. User queries a CS-W to determine if needed imagery is available (Data discovery use case for) 3. No imagery meeting data currency requirements is available 4. Airborne and spaceborne collections are tasked 5. (Optional) User requests collection status from SPS or CS-W	

6. Collection status provided to user through SPS response or user is notified
7. (Optional) User modifies tasking for sensor and platform
8. Collection status provided to user through notification service
9. Collection delivered to a Data Server
10. User notified of collection status and access instructions through notification service
11. Automated delivery of image products occurs.
12. Workflow processing will occur using WPS/WCTS and other classification services
13. Processed results will be make accessible
14. Automated delivery of processed image products occurs.

4.1.4.1.4 Georeferenceable Imagery

Catalog search to discover a Sensor Observation Service that can provide JPEG 2000 compressed imagery complete with sensor parameters and/or functional fit parameters over a user defined area falling within a user defined set of temporal parameters. Catalog search for a JPIP enabled WCS-T that can access and interactively deliver that image data with the sensor/functional fit parameters. Integrated Client constructs the get coverage request for the image data and the associated parameter information with Output = JPEG2000 Interactive Protocol. Integrated Client then enables the user to interactively select the Area(s) of Interest (at varying resolutions and quality). Once the user has the desired AOI in view, the user saves the compressed data for the AOI and associated parameter information into a self-contained package for exchange that can independently support geopositioning of the selected subset of the source imagery.

4.1.5 SWE Information Viewpoint

SWE Information viewpoint describes a coherent information model or set of integrated information models for distributed sensor environments. The specific information models and associated service interfaces are shown below:

Document Name	Searchable Sections/Tags
SOS Capabilities	OWS common section (like any other service) For each observation in the offering list: - observation id, name and description - observed property (association with O&M phenomenon object) - procedure id (association with SensorML sensor object) - feature of interest (association with GML feature) - time range - location (if fixed) - format

SPS Capabilities	OWS common section (like any other service) For each sensor system in the offering list: - phenomenon urn (association with O&M phenomenon object) - sensor id (association with SensorML sensor object) - area of service
SAS Capabilities	OWS common section (like any other service) For each subscription in the offering list: - alert id, name and description - observed property (association with O&M phenomenon object) - procedure id (association with SensorML sensor object) - feature of interest (association with GML feature) - time range - location (if fixed) - format
SensorML Sensor, System and Process	Most information is contained in the metadata group - description - identifiers - classifiers - time, legal and security constraints - characteristics - capabilities - contacts - inputs and outputs (association with O&M phenomenon) - taskable parameters (association with O&M phenomenon) ➔ eventually recurse for each sub components
O&M Phenomena	A phenomenon is intended to be a pure dictionary entry, so it should be parsed in its entirety, including: - description - name - base phenomenon (association with other O&M phenomenon) - constraint phenomenon (association with other O&M phenomenon)

	- constraint value - component if composite (association with other O&M phenomenon)

The following diagram illustrates the relationship of the SWE information models to each other and to the service models. Portions of the GML and SWE Common schemas, shown on the left of the diagram, are used to provide core information elements for the SWE Information Models. This constitutes the common encodings which are used to facilitate interoperable data and metadata exchange.

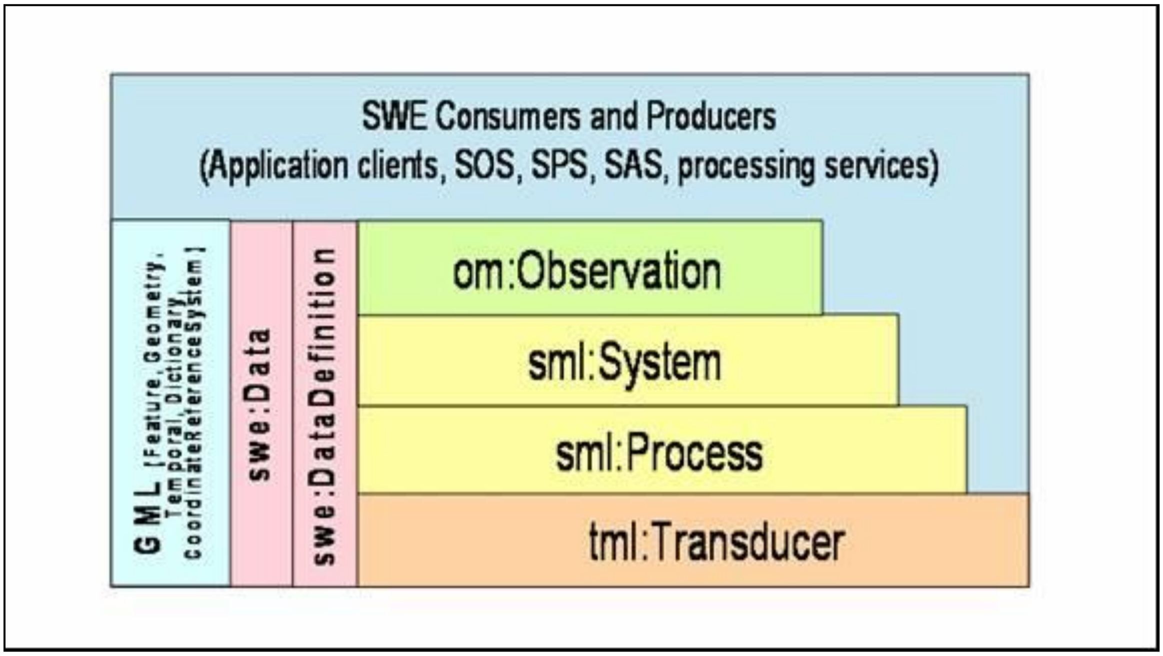


Figure 5: SWE information models as they relate to other service models

4.1.6 SWE Computational Viewpoint

Within the SWE initiative, the enablement of such sensor webs is being pursued through the establishment of several encodings for describing sensors and sensor observations, and through several standard interface definitions for web services. Sensor Web Enablement standards that have been built and prototyped by members of the OGC include the following OpenGIS Specifications:

1. Sensor Model Language (SensorML) – standard models and XML Schema for describing the processes within sensor and observation processing systems; provides information needed for discovery, georeferencing, and processing of observations, as well as tasking sensors and simulations.

2. Observations & Measurements (O&M) - The general models and XML encodings for observations and measurements made using sensors.

3. Transducer Model Language (TML) –XML encoding for supporting real-time streaming observations and tasking commands to and from sensor systems.

4. Sensor Observation Service (SOS) – An open interface for a service by which a client can obtain observations and sensor and platform descriptions from one or more sensors.

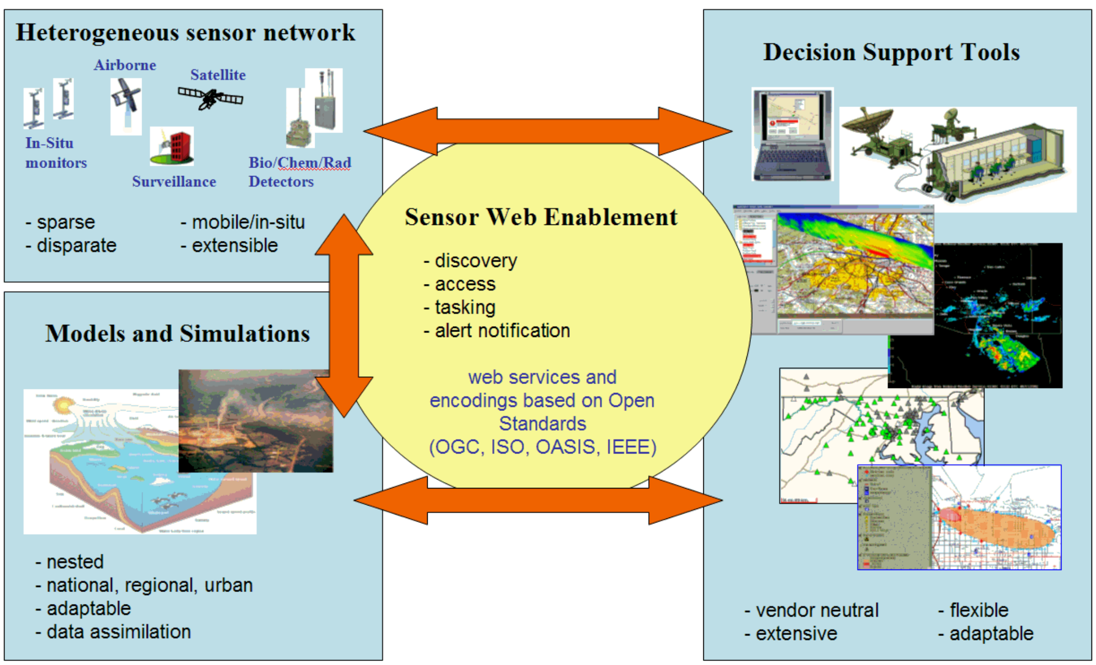
5. Sensor Planning Service (SPS) – An open interface for a service by which a client can 1) determine the feasibility of collecting data from one or more sensors or models and 2) submit collection requests to these sensors and configurable processes.

6. Sensor Alert Service (SAS) – An open interface for a web service for publishing of and subscribing to deliverable alerts from sensor or simulation systems.

7. Web Notification Service (WNS) – An open interface for a service by which a client may conduct asynchronous dialogues, or message interchanges, with one or more other services.

4.1.7 SWE Engineering Viewpoint

The SWE architecture was designed to enable the creation of web-accessible sensor assets through common interfaces and encodings. Sensor assets may include the sensors themselves, observation archives, simulations, and observation processing algorithms. SWE not only enables interoperability among disparate networks of sensors and among disparate models and simulations, but it also enables increased interoperability between sensors and models, and the decision support tools where the final application of observations occurs.



M. Botts -2004

Figure 6: The role of SWE

The Sensor Web Enablement (SWE) architecture was designed to enable the creation of 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 6. 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.

4.2 Geo-Processing Workflow (GPW)

4.2.1 GPW Scope

The Geo-Processing Workflow (GPW) thread aims to develop and demonstrate interoperability among geo-processes through service chaining, workflow and web services, with emphasis on the Web Processing Service (WPS) and SOAP bindings. The results will be realized through valued-added enterprise scenarios that demonstrate the power of interoperability and service-oriented architectures. The OWS-5 GPW thread aims to integrate and enhance OGC web services specifications drawing on accomplishments of previous initiatives to meet these objectives.

The main themes in the GPW thread are as follows:

- Service Chaining and Workflow
- SOAP/WSDL Bindings for OWS Services
- Web Processing Service Profiles
- Streaming of Imagery in OWS
- Access to and Processing of Predictive Models
- OWS Integrated Clients

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4.2.2 GPW Requirements

This section contains the requirements for developments in the GPW thread of OWS-5.

The requirements in the following table are grouped into the following categories:

1. Refine OWS Architecture for Enterprise Integration
2. Service Chaining and Workflow
3. SOAP/WSDL Bindings for OWS Services
4. Web Processing Service Profiles for Workflow Scalability
5. Streaming of imagery in OWS
6. Access to and Processing of Predictive Models
7. OWS Context in the workflow
8. GeoRM in the workflow
9. OWS Integrated Clients

1) Refine OWS Architecture for Enterprise Integration
a) Refine and document loosely-coupled integration of OGC Web Services in a service oriented architecture for enterprise.
b) Prepare an updated Workflow Architecture IPR to document associated work performed in this testbed
c) Support investigation and contribute to IPR on use of the Task-Post-Process-Use (TPPU) pattern through coordination with SWE thread.

	d) Perform a study to investigate workflow performance based on factors such as networks considerations, separation of control and data, implementation platform, architecture, composition of services and other design choices.
2)	Service Chaining and Workflow
	a) Implement a BPEL engine and workflows to produce geospatial content (maps, features, coverages, etc.)
	b) Investigate and report on use of standards and notations (such as BPMN and XPDL) in support of design and implementation of BPEL workflow processes
	c) Integrate OGC core web services such as WMS, WFS, WFS-T, WCS, WCS-T, and CS/W in workflow including use of GMLJP2 and JPIP.
	d) Integrate OGC SWE web services such as SOS, SAS, SPS, and WNS in workflow (see SWE thread for related service enhancement efforts)
	e) Use WPS profiles execute algorithms as links in a geo-processing service chain
	f) Develop workflow(s) to process observations from the SWE thread into features and coverages using services which should include SOS, SAS, SPS, and WNS
	g) Specific workflows will be developed to support scenarios that create information of value to end-users.
3)	SOAP/WSDL Bindings for OWS Services
	a) Investigate and document potential OWS Common enhancements and recommendations to reduce overlap between specifications and harmonize services
	b) Develop recommendations to harmonize OWS services at the interface and object definition level.
	c) Define a common approach for developing SOAP and WSDL bindings for OGC web services.
	i) SOAP interfaces shall be compliant with the appropriate profiles for W3C and OASIS specifications defined by the Web Services Interoperability Organization (http://ws-i.org): WS-I Basic Profile 1.0, Simple SOAP Binding Profile 1.0, Attachments Profile 1.0
	ii) Develop guidance on WSDL implementation endpoints, e.g., should a single WSDL describe all operations (getCapabilities, describeFeature, getFeature) or should a separate WSDL for each operations (or both) be used.
	d) Define SOAP bindings for WFS, WCS, WMS, CSW including Abstract Compliance Clauses.
	e) Define WSDL documents for WFS, WCS, WMS, CSW including Abstract Compliance Clauses.
	f) Implement WFS with SOAP/WSDL bindings
	g) Implement WCS with SOAP/WSDL bindings
	h) Implement WMS with SOAP/WSDL bindings
4)	Web Processing Service Profiles for Workflow Scalability

a) Develop profiles of WPS for access to algorithms in a workflow. To define a WPS profile, the WPS operations are to be used as the core with extensions defined for the specific algorithm, i.e., Profile is the WPS core plus extensions for the specific algorithm, e.g., image processing. Develop approaches for scaling WPS profiles considering the multiple types of processing services, is on the order of 50.
b) WPS profile for Image Processing
i) Implement a WPS for Image Processing that will interface with an SOS producing a geo-referenceable image to produce geo-rectified imagery encoded with functional fit parameters provided in SensorML
ii) Define this WPS profile using the Image Geopositioning Service
iii) Provide a WCS that will allow interactive access to JPEG 2000 compressed 'smart' imagery using GMLJP2 and JPIP.
iv) Process geo-referenceable output from an SOS via WCS-T in GMLJP2 or JPIP format to produce geo-rectified imagery
v) Process geo-referenceable output from an SOS via WCS-T (without rectification) to produce a JPIP output and stored for later use, as needed.
c) WPS - Earth Observation. WPS for processing of Earth Observation application, for example see OWS-4 EO Scenario with examples of flood detection algorithm, and hurricane area of impact detection. Other examples include air quality threshold algorithm, wildfire detection algorithm, etc.
d) Web Processing Service profile for Conflation.
i) Design and implement a WPS for Conflation. The service shall provide rules based conflation capability; shall be automated as much as possible; and implemented within a BPEL workflow.
ii) WPS-Conflation may reuse Data Fusion Service from previous OWS testbeds. Also, reuse elements of WFS specification as appropriate.
e) Further develop and implement Topology Quality Assurance Service (TQAS) as a WPS profile building on the TQAS defined in OWS-4. TQAS to be used in OWS-5 workflow.
5) Streaming of imagery in OWS
a) Provide access and manipulation of imagery in a workflow using SOS, WCS, WCS-T and WCPS.
b) Provide access to a georeferenceable, clipped section of an image defining an area of interest with functional fit parameters capable of tying the location of the clip back to the position on the full image
c) Provide JPIP and GMLJP2 capabilities via a client interface to allow interactive access to JPEG imagery maintaining strong correlation with the support and other metadata associated with the imagery
6) Access to and Processing of Predictive Models
a) Develop architectural approaches for access to outputs of predictive models. For example, i) To access model outputs that have been created before requested by a user, use OWS access services, e.g., WMS, WFS, WCS. ii) To access model outputs that are created in response to user inputs use WPS. Different profiles of WPS may be needed for example based upon the type of user defined input.

	b) Investigate and implement various binary grid processing methods using subsets of data that can be extracted from predictive model results as well as for final portrayal of data
	c) Process image data through a WCTS before sending to the binary processing service.
	d) Define metadata for the model to create a catalogue entry for the model access service.
7)	OWS Context in the workflow
	a) Refine and document the OWS Context definition in collaboration with information modeling effort on OWS Context to be performed in Agile Geography thread
	b) Implement OWS Context to identify and publish collected sources as part of workflow
8)	GeoRM in the workflow
	a) Investigate, define and, at least partially, implement OGC web services capabilities necessary to address authorization/authentication methods and technologies in support of DCID 6/3 requirements
	b) Define and implement a trust model for end-user licenses as described in the Distributor Use Case
	c) Investigate and report on concepts of Identity 2.0, OpenID and PKI as they relate to GeoRM Reference Model and how they may affect, influence or be used to define future directions in GeoRM
	d) Define and implement an OGC Web service interface based on WS-Trust for the License Manager / License Broker
	e) Define and implement a prototype framework to dynamically negotiate a license needed for a request based on WS-Trust
	f) Define and implement license encoding using a combination of SAML and GeoXACML
	g) Investigate cascading scenarios involving GeoRM licenses and authentication of entities
9)	OWS Integrated Clients
	a) OWS Integrated Clients are clients of: Web Map Server (WMS), Web Feature Server (WFS), Feature Portrayal Service (FPS), Coverage Portrayal Servers, Web Coverage Server (WCS), Catalog Service – Web (CS/W), Web Processing Servers (WPS) Sensor Planning Service (SPS), Sensor Observation Service (SOS), and Context Documents
	b) Client software must be able to execute a scenario driven production flow taking advantage of BPEL, dynamic chaining of services and other workflow management capabilities where possible.
	c) Integrated Client to access catalogues/registries in the ICS thread.
	i) Client must be able to discover schemas and data registered on a catalog or catalogs using both DDMS and ISO 19139 metadata search
	ii) A client must be able to search a catalog for available views, by using keywords
	iii) The client must present the user with a selection of views from the return list
	iv) The client automates the query of feature types that are associated with that view
	v) The client automatically constructs GetFeature request with all the feature types in the view
	vi) Client must provide the capability to register “stored queries” back on the OGC Catalogue.

	vii) The client must be able to query across catalogs to discover multiple WFS that can satisfy the feature type requirements from the view
	viii) The client retrieves and portrays the features in the view from the WFS(s)
d)	Decision Support Tools such as those cited in NASA's national applications (e.g. Phairs, Airnow)

Table 2 – GPW Requirements

4.2.3 GPW Deliverables

The following Interoperability Program Reports (IPRs) will be developed in the Geo-Processing Workflow thread and submitted to the OGC Specification Program at the completion of the OWS-5 Testbed.

Interoperability Program Reports (IPRs)

1) OWS Workflow Architecture IPR
2) OWS SOAP/WSDL Common IPR
3) WPS - Conflation IPR
4) WPS - EO Algorithm IPR
5) WFS 1.2 Change Request IPR
6) GeoDRM Engineering CR IPR
7) Security IPR

Implementations of the following services, tools and data instances will be developed in this OWS-5 thread, tested in Technology Integration Experiments (TIEs) and invoked for cross-thread scenarios for OWS-5 demonstration events.

Components, Services, Data or Tools

1) WFS-T 1.2 plus SOAP/WSDL
2) WCS-T 1.1 plus SOAP/WSDL
3) WMS 1.3 plus SOAP/WSDL
4) OWS Integrated Client
5) BPEL workflow scripts
6) BPEL Workflow engine
7) WPS - Conflation Service
8) WPS - EO Algorithm
9) WCPS
10) WPS- Topology Quality Assessment Service (TQAS)
11) WPS – Generalization Service
12) WPS - Clipping Service
13) GeoDRM Services

4.2.4 GPW Enterprise Viewpoint

4.2.4.1 GPW Objective

The work of OGC Interoperability and Specification Programs has produced a significant body of knowledge and experience in designing, building and deploying Web Services. The full potential of OGC Web Services as an integration platform will be achieved when applications and business processes can be composed to perform complex interactions using a standard process integration approach. The OASIS Web Services Business Process Execution Language (WS-BPEL, commonly referred to as BPEL) offers a language to meet this need where business processes can be implemented via web services so that cooperating entities can perform one or more steps in a process.

The Geo-Processing Workflow (GPW) thread builds on accomplishments of several previous initiatives. Beginning with OWS-2, the Image Handling for Decision Support (IH4DS) thread extended the baseline of OWS service types with image processing services and began use of BPEL. In OWS-3 the Common Architecture thread continued this work by applying the services developed in OWS-2 to the SWE and GeoDSS environments. In OWS-4, a baseline approach for OWS Workflow using BPEL was established and demonstrated in several scenarios. Several processing services were defined as profiles of the Web Processing Service, e.g., Topology Quality Assessment Service, Model Output Processing Service. This architecture was documented in the OWS-4 Workflow Architecture Discussion Paper (OGC 06-187r1).

The Geo-Processing Workflow (GPW) thread in this testbed aims to develop and demonstrate interoperability among geo-processes through publish-find-bind, service chaining and workflow orchestration. The results will be realized through valued-added enterprise scenarios that demonstrate the power of interoperability and service-oriented architectures. The OWS-5 GPW thread aims to integrate and enhance OGC web services specifications drawing of accomplishments of previous initiatives to meet these objectives.

4.2.4.2 Support of Strategic Objectives

4.2.4.2.1 NGA/NCGIS

NGA/NCGIS is engaging the OGC Interoperability Program to fulfill one of the modernization goals for the National System for Geospatial Intelligence (NSG). This goal is to increase NGA's capabilities to leverage existing market driven Standards–based Commercial Off-The-Shelf (SCOTS) solutions for fulfilling analyst's needs in undertaking their missions. Part of NCGIS's mission is to ensure that commercial industry addresses NGA interoperable technology requirements. The NCGIS, through efforts such as the OGC Interoperability Program, works to ensure standards and standards based commercial software, addressing NGA requirements, are ready for implementation when the GeoScout contractor working with their industry team is ready for that phase of modernization of NGA's information technology (IT) infrastructure. NGA is also committed to supporting interoperability with other mandated e-Government initiatives. All activities / products contained in this statement of work may also be used to test and strengthen net centric compliance with open standards.

OWS-5 will facilitate OGC and industry vendors to develop, test and validate interface specifications, which are anticipated to lead to commercial products suitable for use by NGA, its customers and the broader federal geospatial community.

4.2.4.2.2 Task-Post-Process-Use (TPPU) Pattern

The goal of the transformation towards TPPU pattern is to "ensure that operators as well as intelligence analysts get robust information targeted to their specific needs when they need it, and that rather than a large amount of information provided to a small number of people, all information (based on clearance and security certification) is available to a large number of people."

- (ref: http://horizontalfusion.dtic.mil/about/net-c.html)

DTIC Website discusses TPED and TPPU in context of Net-Centric Warfare and Horizontal Fusion

- http://horizontalfusion.dtic.mil/about/net-c.html

State Machine Modeling of TPED and TPPU

- (http://www.dtic.mil/ndia/2005systems/thursday/sorensen.pdf)

4.2.4.2.3 Director of Central Intelligence Directive (DCID) 6-3

The DCID 6/3 model is based on certification and accreditation performed on information systems that are characterized by Protection Levels (PL), and DCID 6/3 defines five different protection levels. DCID 6/3 deals only with classified information and its PL model helps ensure that only properly cleared people have access to classified information. Although the DCID 6/3 model was designed for classified information and intelligence work, it is publicly available for review, and any agency or private organization can adopt the methodology, and customize it according to their own unique requirements. The DCID Standards Manual, which defines the DCID 6/3 certification and accreditation process, can be found on the Federation of American Scientists Web site:

- (ref: http://209.85.165.104/search?q=cache:YZ1r6qz-_KQJ:www.fas.org/irp/offdocs/dcid-6-3-manual.pdf+site:www.fas.org+DCID+Standards+Manual&hl=en&ct=clnk&cd=7&gl=us)

4.2.4.2.4 NASA's Applied Sciences Program

NASA's Applied Sciences Program within the NASA Earth Science Division seeks:

> *To integrate NASA Earth science research results into decision support systems serving applications of national priority and to document improvements in the performance of the decision support systems.*

The overall objective of these projects is the sustained use of geosciences products and NASA Earth science research by operational organizations in their decision-making activities to benefit the nation and society.

The Applied Sciences Program enables the use of results from NASA Earth science research in operational decision support systems (DSS) that organizations employ to serve their management, business, and policy responsibilities. The overarching purpose of the Applied Sciences Program is to showcase the value of NASA Earth science research and technology and to maximize the societal benefits of the nation's investments in the NASA Earth science research program.

The Program focuses on extending Earth science research results to decision support systems in twelve areas of national priority:

Agricultural Efficiency	Air Quality	Aviation
Carbon Management	Coastal Management	Disaster Management
Ecological Forecasting	Energy Management	Homeland Security
Invasive Species	Public Health	Water Management

Figure 7 illustrates the Integrated System Solutions (ISS) architecture that the Applied Sciences Program uses to depict the contributions of Earth observations and models to organizations' decision-making activities.

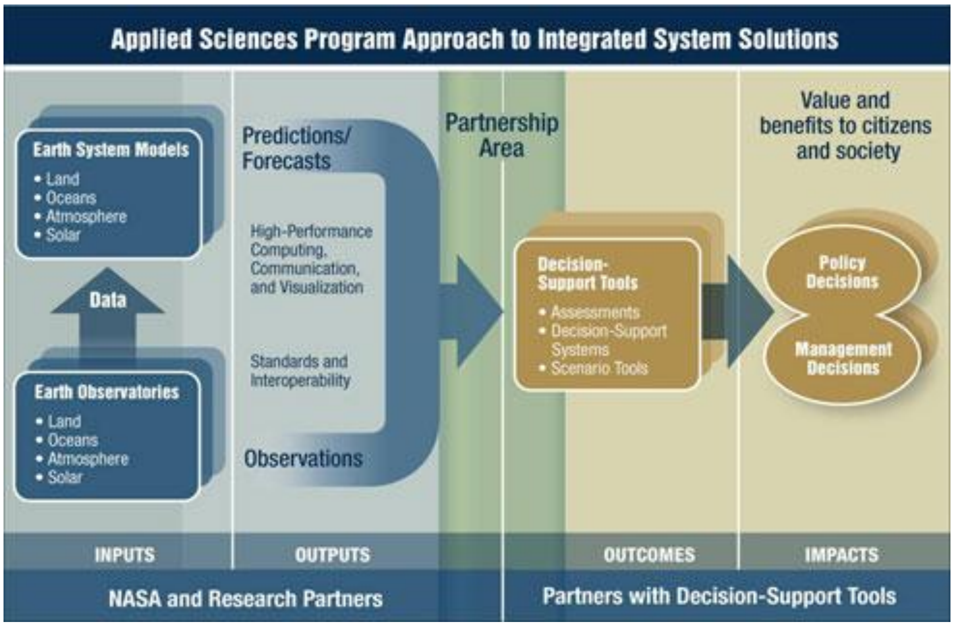


Figure 7: NASA Integrated System Solutions

4.2.4.3 GPW Use Cases

4.2.4.3.1 Use Case #1: OGC Web Services for "georeferenceable" imagery

Use Case Identifier: GPW #1	Use Case Name: OWS for "georeferenceable" image streaming
Use Case Domain: OWS-5 GPW Thread	Status: Under development.
Use Case Description: Allow a user to interactively access pixels from a coverage service stored in the compressed domain (JPEG2000) and preserve the image relationship with the associated 'sensor model' parameters such that precise geopositioning capabilities can be realized on a subset of the image in a dynamic, interactive, networked environment. Imagery is provided in a time sensitive response to the client without processing while also initiating a workflow script to geoposition the imagery.	
Actors (Initiators): Image source and Image analyst.	Actors (Receivers) Image analyst.
Pre-Conditions: - User requires imagery of a geo-location. - Workflow script has been created to geo-positioning a geo-referencable image.	Post-Conditions: - Image analyst rapidly receives the un-processed image. - Image analyst receives a portion of the image geo-referenced using RPC.

System Components - SOS with interactive, streaming capability including sensor parameters. Only a portion of the large (100s GB) image is to be transferred along with the sensor parameters specific to the image subset. - WCS or WCS-T to accept and cache image subset; and to subsequently provide access to a georeferenceable, clipped section of an image defining an area of interest with functional fit parameters capable of tying the location of the clip back to the position on the full image - WPS for Image Geo-positioning Service, including ancillary inputs of DEM and RPC coefficients - SensorML instance document containing RPC coefficients - Workflow Execution Engine and other OWS services as needed. - Client with access to 1) the SOS directly for the image stream and 2) workflow process.
Basic Course of Action: 1. SOS provides access interactive access transferring ~100MB subset of the image and the sensor model applicable to the image subset. (This transfer is accomplished with JPIP and should build on WCS-JPIP and GMLJP2. 2. Client receives image subset while preserving the relationship of the image/coverage pixel coordinate index with the associated sensor parameters, adjustable parameters and error-propagation data so that the client can use whatever physical sensor model or Rapid Positioning Capability positioning tool available to the client to do precise geopositioning using the pixels interactively pulled from the server. 3. A workflow is initiated including use of an WPS- Image Geopositioning Service. This requires the coverage service, the JPIP protocol service, the geopositioning service and the client would need to be 'logically' in sync with the interactive transfer of pixels. 4. Input to the WPS - IGS will include Terrain Data, sensor model/RPC, and the full image 5. Output from the IGS will be a geo-rectified image encoded in GMLJP2 for input into the JPIP enabled WCS and to client.

4.2.4.3.2 Use Case #2: GeoDRM enabled web services (authorization/authentication)

Catalog search to discover WFS that contains features supporting Local MSD (GML 3.2.1). Response indicates multiple WFS that support Local MSD in GML 3.2.1. User requires Catalog search to discover if those WFS support the concept of MSD Views. Response indicates all WFS support Views.

Integrated Client builds query for views to gather data content to support transportation, aerodrome, and population. Feature content to match views is retrieved and a BPEL workflow is executed to merge and conflate the data, process through a Clipping Service to cut to a user specified bounding box, send on to a Generalization Service to remove duplicate vertices and vertices that fall within a user defined tolerance, then to execute the Topology Quality Assessment Tool to auto correct any transportation disconnects. The resulting data served through a WFS-T with output = KML and making use of SLD/SE is accessed by a field analyst using a handheld PDA. The field analyst inserts new building structures on the aerodrome and marks several buildings surrounding the aerodrome as condition of facility = abandoned. The data is uploaded to the WFS-T and retrieved by the Integrated Client with the WFS-T output = GML 3.2.1

4.2.4.3.3 Use Case #3: Earth Observation Use Case

Objective: to develop the elements of OWS necessary to support an EO Scenario involving discovery, integration, processing, chaining and visualization of earth observations and model outputs .

Use Case Identifier: GPW #3	Use Case Name: OWS for Earth Observation	
Use Case Domain: OWS-5 GPW Thread		Status: Under development.

<table>
<tr><td colspan="2">Use Case Description:

This use case applies OWS workflow and SWE to an Earth Observation scenario. The scenario demonstrates the application of standards in describing, discovering, accessing and tasking satellites and ground-based sensor installations in a sequence of analysis activities that deliver information required by decision makers in response to national, regional or local emergencies.</td></tr>
<tr><td>Actors (Initiators): Image source and Image analyst.</td><td>Actors (Receivers) Image analyst.</td></tr>
<tr><td>Pre-Conditions:
- Decision maker needs information to support emergency response.
- Sensors have been deployed and are taskable
- Workflow script has been written to create value-added information.</td><td>Post-Conditions:
- Decision maker has the latest available information.
- Decision maker has developed an operational understanding of the emergency situation.</td></tr>
<tr><td colspan="2">System Components
- Sensor Observation Service (SOS)
- Sensor Planning Service (SPS)
- Sensor Alert Service (SAS)
- Web Processing Service (WPS)
- Catalog Service for the Web (CSW)
- Web Coverage Service (WCS)
- Web Feature Service (WFS)
- Web Map Service (WMS)</td></tr>
<tr><td colspan="2">Basic Course of Action:
1. Quickly discover relevant and up-to-date assets, services and sensors
2. Order real-time custom products with guaranteed delivery to any location in the world
3. Subscribe to data/service/sensor feeds and getting real-time notifications when information is available
4. Integrate needed data on the web (using a click-through license for trusted identity providers)</td></tr>
</table>

4.2.4.3.4 Use Case #4: GeoRM Distributor License Use Case

<table>
<tr><td>Use Case Identifier: GPW #4</td><td colspan="2">Use Case Name: GeoRM Distributor License</td></tr>
<tr><td colspan="2">Use Case Domain: OWS-5 GPW Thread</td><td>Status: Under development. Draft 12/17</td></tr>
<tr><td colspan="3">Use Case Description:

This use case describes “distributor” rights to WMS map layers. The provider of a cascading WMS operates under a license with an originating WMS to re-distribute on its own one or more map layers to clients under an unrestricted use license.</td></tr>
<tr><td>Actors (Initiators): User of WMS and provider of cWMS</td><td colspan="2">Actors (Receivers) Same as initiators</td></tr>
<tr><td>Pre-Conditions:</td><td colspan="2">Post-Conditions:</td></tr>
</table>

- User requires WMS map layers. - User has access to WMS client. - cWMS provider is able to cascade map layers from one or more originating WMS Servers	WMS map layers are viewable within the user's WMS client software.
System Components - CS/W: Catalog Service Web Profile - WMS: Web Map Service - cWMS: Cascading Web Map Service - License Broker: presents license offers and establishes licenses - License Manager: stores and matches licenses - License Gatekeeper: decides whether a specific request is valid under a specific license - License Enforcer: "security" implements authentication of license decision elements and authorization of consequences	
Basic Course of Action: 5. cWMS provider establishes a distributor license with an originating WMS for one or more map layers and receives a license acknowledgement token. 6. User queries a CS/W and/or the cWMS to determine if needed map layers are available and under what terms 7. User selects layers of interest 8. GeoDRM Client obtains terms of use 9. User agrees to terms 10. Broker Server stores established license and returns acknowledgement token 11. WMS/GeoDRM Client issues map layer request to cWMS with license acknowledgement token. 12. Gatekeeper Server validates identity of user and authenticity of license information, decides whether license applies to request. 13. cWMS issues map layer request to originating WMS with its own (distribution license) acknowledgement token 14. WMS returns map layer to cWMS 15. cWMS returns map layer(s) to client.	

4.2.5 GPW Information Viewpoint

This viewpoint explains the data models in the systems.

4.2.5.1 BPEL (and BPMN, XPDL)

Relevant Specifications:

– OASIS Web Services Business Process Execution Language Technical Committee WS-BPEL 2.0 (ref: www.oasis-open.org)
– Business Process Modeling Notation (BPMN) (ref: www.bpmn.org)
– XML Process Definition Language (XPDL) (ref:: www.wfmc.org)

The Business Process Execution Language for Web Services (WS-BPEL4 or BPEL for short) defines a notation for specifying business process behavior based on Web Services. It is a standard promoted by Microsoft, IBM, Siebel, SAP and BEA for orchestrating discrete services into end-to-end business processes. Processes defined in BPEL can export and import functionality by using Web Service interfaces exclusively. BPEL provides a language for the formal specification of business processes and business interaction protocols. By doing so, it extends the Web services interaction model and enables it to support business transactions. BPEL defines an interoperable integration model that should facilitate the expansion of automated process integration in both the intra-corporate and the business-to-business spaces.

Business processes can be described in two ways. Executable business processes model actual behavior of a participant in a business interaction. Business protocols, in contrast, use process descriptions that specify the mutually visible message exchange behavior of each of the parties involved in the protocol, without revealing their internal behavior. The process descriptions for business protocols are called abstract processes.

Business Process Modeling Notation (BPMN) - a standardized graphical notation for drawing business processes in a workflow. BPMN was developed by Business Process Management Initiative (BPMI), and is now being maintained by the Object Management Group since the two organizations merged in 2005.

The primary goal of BPMN is to provide a standard notation that is readily understandable by all business stakeholders. These business stakeholders include the business analysts who create and refine the processes, the technical developers responsible for implementing the processes, and the business managers who monitor and manage the processes. Consequently BPMN is intended to serve as common language to bridge the communication gap that frequently occurs between business process design and implementation.

XPDL - used as a file format for BPMN. The XPDL and the BPMN specifications address the same modeling problem from different perspectives. XPDL provides an XML file format that can be used to interchange process models between tools.

BPEL and XPDL are entirely different yet complimentary standards. BPEL is an "execution language" designed to provide a definition of web services orchestration, specifically the underlying sequence of interactions, the flow of data from point-to-point. For this reason, it is best suited for straight-through processing or data-flows vis-a-vis application integration. The goal of XPDL is to store and exchange the process diagram, to allow one tool to model a process diagram, and another to read the diagram and edit, another to "run" the process model on an XPDL-compliant BPM engine, and so on. For this reason, XPDL is not an executable programming language like BPEL, but specifically a process design format that literally represents the "drawing" of the process definition.

4.2.5.2 GML in JPEG 2000 for Geographic Imagery Encoding Specification (GMLJP2)

Relevant Specifications:

- OpenGIS® GML in JPEG 2000 for Geographic Imagery Encoding Specification (GMLJP) 05-047r3

The GML (Geography Markup Language) is an XML grammar for the encoding geographic information including geographic features, coverages, observations, topology, geometry, coordinate reference systems, units of measure, time, and value objects. JPEG 2000 is a wavelet based encoding for imagery that provides the ability to include XML data for description of the image within the JPEG 2000 data file. This specification defines the means by which GML is to be used within JPEG 2000 images for geographic imagery. This includes the following: · Specification of the uses of GML within JPEG 2000 data files. Packaging mechanisms for including GML within JPEG 2000 data files. · Specific GML application schemas to support the encoding of OGC coverages within JPEG 2000 data files.

4.2.5.3 OWS Context

Relevant Document:

- OGC Web Services Context Documents (OWS Context) Interoperability Experiment: FINAL REPORT (OGC Doc No. 05-062)

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).

4.2.5.4 Web Map Context

Relevant Specification:

- OpenGIS® Implementation Specification (WMC) 1.1 (OGC Doc No. 05-005, 2005-05-03)

Web Map Context is a companion specification to the OGC Web Map Service Interface Implementation Specification version 1.1.1. The WMS specifies how individual map servers describe and provide their map content. The present Web Map Context specification states how a specific grouping of one or more maps from one or more map servers can be described in a portable, platform-independent format for storage in a repository or for transmission between clients.

4.2.6 GPW Computational Viewpoint

This viewpoint is deals with the service architecture, specific services and the services interactions to be used in the GPW thread.

4.2.6.1 Enterprise Workflow Architecture

The GPW architecture was documented in the OWS-4 Workflow Architecture Discussion Paper (OGC 06-187r1).

The Geo-Processing Workflow (GPW) thread in this testbed aims to develop and demonstrate interoperability among geo-processes through publish-find-bind, service chaining and workflow orchestration. Workflow through loosely-coupled integration of OGC web services in a service-oriented architecture is an objective of GPW.The results will be realized through valued-added enterprise scenarios that demonstrate the power of interoperability and service-oriented architectures. The OWS-5 GPW thread aims to integrate and enhance OGC web services specifications drawing of accomplishments of previous initiatives to meet these objectives.

The goal of this task area is to implement a representative, end-to-end service lifecycle for the Publish-Find-Bind (P-F-B) pattern using service chaining and workflow for OGC web services and other supporting capabilities.

- This task will prepare an Enterprise Workflow Architecture IPR to document the implemented architecture for the workflow integration across the thread; and should document lessons learned as a result of this work in the testbed.
- Perform a study to investigate workflow performance as it relates to implementation platform, architecture, and composition of services.
- Conduct a Workflow Performance trade study of various workflow configurations and design choices to assess how these configurations affect performance of a workflow environment (e.g.,

how does breath of distribution affect the topology of the chain). Results of this study should lead to better understanding of how implementation platform, architecture, composition of services and other design choices affect performance given the variations in network performance, distributed services, data sizes, administrative domains, etc. This task should consider the approach taken in the OWS-3 GML Performance Study now a Discussion Paper (OGC Doc 05-050).

4.2.6.2 Workflow Chaining Service (WfCS)

***Relevant Documents**:*

- OWS 2 Service Chaining with BPEL Discussion Paper (OGC 04-078)
- OWS-4 Workflow IPR (OGC doc 06-187r1)
- OASIS Web Services – Business Process Execution Language (WS-BPEL) 2.0

Implement a BPEL engine and several workflow scripts to produce content (maps, features, coverages, etc.) suitable for decision-makers needs. BPEL workflows should be designed to execute several process steps composed of a variety of OGC web service capabilities and functions. While some OGC web service implementations in this thread call for use of SOAP bindings and WSDL, other web services to be integrated with the workflow may use either a REST-type interface or SOAP.

Investigate and report on use of standards and notations (such as BPMN and XPDL) in support of design and implementation of BPEL workflow processes and serve to complement the development and understanding of workflow processes.

The Workflow Chaining Service (WfCS) executes workflow processes and correlates and coordinates synchronous interactions into collaborative and transactional business flows. It is an infrastructure service for modeling, connecting, deploying and managing and executing business processes.

For each process, the WfCS uses a BPEL script that describes the workflow or processing chain to be executed, a WSDL document (without binding information) that describes the interface that the process will present to clients (*partners* in BPEL terms), and WSDL documents that describe the service instances that the process may invoke during its execution. From this information, the process is made available as a Web Service. A WSDL file that describes the process's interface may be retrieved from the WfCS at run-time.

As described in ISO 19119, there are many possible approaches to composing chains of processing services into aggregate or compound service components. General patterns can be used to describe these approaches based on, for example, the visibility of the services to the user (or client application) as well as the difference in how control of the services is managed. Using these criteria, the following service chaining patterns include (Figure 8):

1. User defined (transparent) chaining: the client application manages the workflow and control of the chain is exclusively with the user of the client application

2. Workflow-managed (translucent) chaining: in which the client application invokes a Workflow Management service that controls the chain and the user is aware of the individual services; a workflow service controls the chain execution, perhaps with oversight by the human user of the client application

3. Aggregate service (opaque): in which the client application invokes a service that carries out the chain, with the user having no awareness of the individual services; the aggregate service exclusively performs the control function with no visibility by the client application. [*OWS 2 Service Chaining with BPEL Discussion Paper (OGC 04-078*]

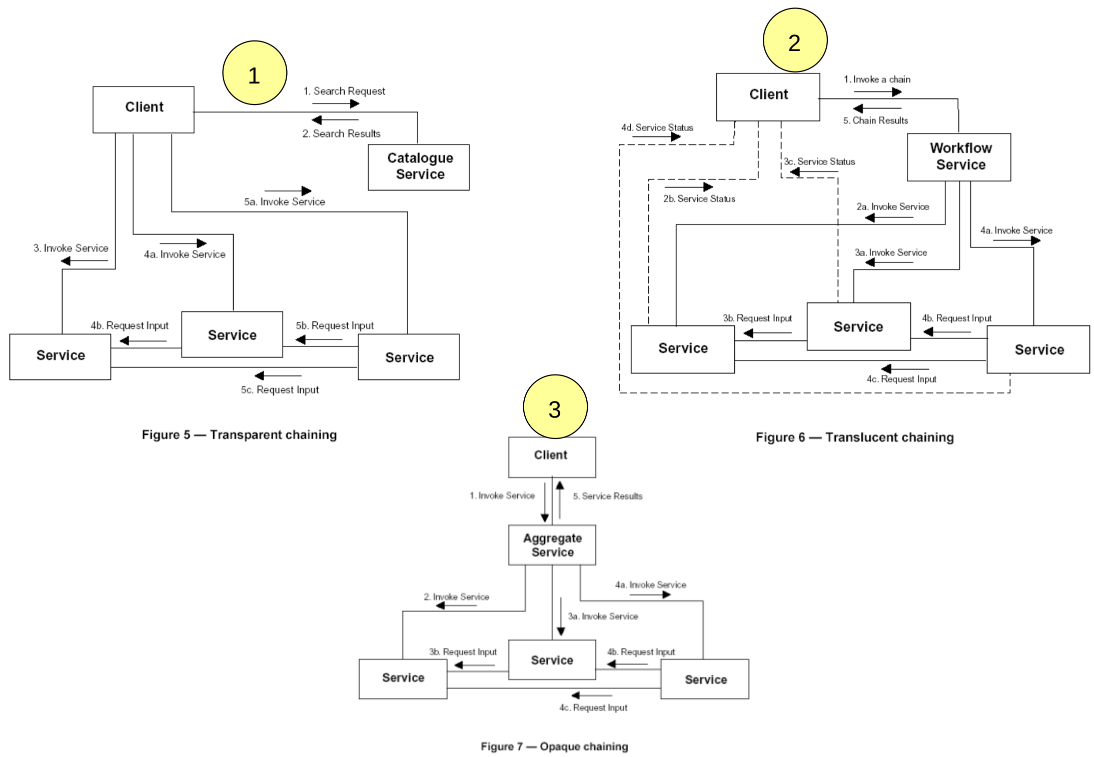


Figure 8: Service Chaining Patterns

4.2.6.3 Web Processing Service (WPS)

Relevant Specifications:

− OpenGIS® Web Processing Service (WPS), OGC document 05-007r5

The Web Processing Service (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 generic interface 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 to be developed to support use, and standardized to support interoperability. As with the other OGC specifications, it is the development, publication, and adoption of profiles which define the specific uses of this specification.

The WPS interface specifies three operations that can be requested by a client and performed by a WPS server, all mandatory implementation by all servers. Those operations are:

1. GetCapabilities – This operation allows a client to request and receive back service metadata (or Capabilities) documents that describe the abilities of the specific server implementation. The GetCapabilities operation provides the names and general descriptions of each of the processes offered by a WPS instance. This operation also supports negotiation of the specification version being used for client-server interactions.

2. DescribeProcess – This operation allows a client to request and receive back detailed information about the processes that can be run on the service instance, including the inputs required, their allowable formats, and the outputs that can be produced..
3. Execute – This operation allows a client to run a specified process implemented by the WPS, using provided input parameter values and returning the outputs produced.

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

A WPS Application Profile describes how WPS shall be configured to serve a process that is recognized by OGC. An Application Profile consists of

1. An OGC URN that uniquely identifies the process (mandatory)
2. A reference response to a DescribeProcess request for that process (mandatory).
3. A human-readable document that describes the process and its implementation (optional, but recommended).
4. A WSDL description (optional in the WPS specification, required in OWS-5).

WPS Application Profiles are intended for consumption by web service registries which maintain searchable metadata for multiple service instances.

4.2.6.4 WPS Interface for Image Processing

This activity will provide a suite of image processing operations accessible via OGC interface.

First, this task should implement a WPS for Image Processing in the workflow. The WPS will interface with an SOS producing a geo-referenceable image [refer to SWE thread] to produce geo-rectified imagery encoded with functional fit parameters provided in SensorML. The geo-processing workflow will use the WPS to process the geo-referenceable image into a geo-rectified image using terrain data and functional fit algorithms. The workflow output could be directly provided to a client application or to a WCS-T.

This task also aims to enhance and further exercise the WCS with JPIP capabilities to build on the results of the work completed in OWS-4 as reported in Discussion Paper OGC Doc 06-182r1 (OWS-4 WPS IPR (Discussions, findings, and use of WPS in OWS-4). GMLJP2 and JPIP shall be used to allow interactive access to JPEG 2000 compressed 'smart' imagery maintaining strong correlation with the support and other metadata associated with the imagery for display and decision support using the two separate Clients.

As shown in Figure 9, two threads of the workflow are anticipated. The first thread of the workflow aims to process the geo-referenceable output from an SOS via WCS-T to produce geo-rectified imagery to be displayed in Client 1 along with other images and maps.

The second thread of the workflow aims to process the geo-referenceable output from an SOS through WCS-T (without rectification) to produce a JPIP output format for display by Client 2 and stored for later use, as needed.

It is desired that Integrated Client 1 and Integrated Client 2 be provided by different vendors. Both clients should offer JPIP capabilities for image display and decision support.

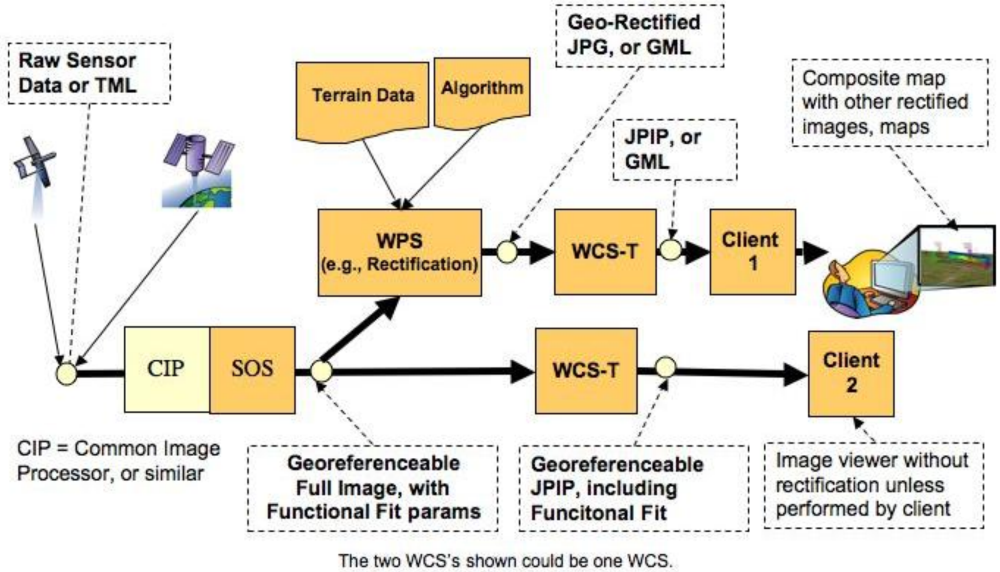


Figure 9: Workflow for Image Processing

4.2.6.5 JPIP and OWS

***Relevant Specification**:*

- JPEG 2000 Part 9, JPIP (interactive protocols and API) (http://www.jpeg.org/jpeg2000/j2kpart9.html)
- OWS-4 IPR for WCS Support for JPEG 2000, OGC Document 06-128

Continue to build on the work accomplished in OWS-4 and prior to enhance WCS with JPIP capabilities. Use JPIP and GML/JP2 to allow interactive access to JPEG 2000 compressed 'smart' imagery maintaining strong correlation with the support and other metadata associated with the imagery.

The main component of JPEG2000, Part 9 is a client-server protocol called JPIP. JPIP may be implemented on top of HTTP, but is designed with a view to other possible transports. To facilitate its deployment in systems with varying degrees of complexity, JPIP handles several different formats for the image data returned by the server: these include ordinary image formats, such as complete JPEG or JPEG 2000 files, and two new types of incremental "stream" that use JPEG 2000's "tiles" and "precincts" to take full advantage of its scalability properties. JPIP also supports both stateless and stateful modes of operation, enabling sophisticated cache-modeling to eliminate the redundant transmission of data.

JPIP provides selective access to the image metadata that may be contained within JPEG 2000 files. Although Part 9 is focused on the application of technology from Part 1, including the JP2 file format, it does support some file format extensions from Part 2. A mechanism has also been provided for selection from amongst multiple codestreams in JPX (Part 2), MJ2 (Part 3) and JPM (Part 6) files. Potentially this could be applied to any file format containing images, not just to the JPEG 2000 family of file formats.

JPIP with OWS is envisioned to support the Image georeferenceable imagery use case, by supporting access to a portion of a large image including the sensor parameters for the subset of the image. For large images, a design requirement is to allow for RPCs specific to portions of the image.

4.2.6.6 SWE Services in the Workflow

This activity will require development of workflow(s) to process observations from the SWE thread into features and coverages suitable for decision support. In general, in order to support the type of workflow depicted in Figure 10, proposing organizations should consider the following:

- Access services
  - WCS and WFS access to persistent store of features
  - Insert data from SWE - Transactional WFS and WCS
- Web Processing Service (WPS)
  - Profile of WPS to meet the SWE processing needs
  - Web Coverage Processing Services (WCPS).
- Service Chaining best practices
  - Workflow engine using BPEL
  - SOAP bindings for OGC web services

The tasks in this thread should take into account and build on the accomplishments from previous testbeds that include:

- OWS-2 IH4DS Service Chaining with BPEL
- OGC Discussion Paper on OWS-3 Imagery Workflow Experiments
- OWS-4 WPS and Workflow IPRs.

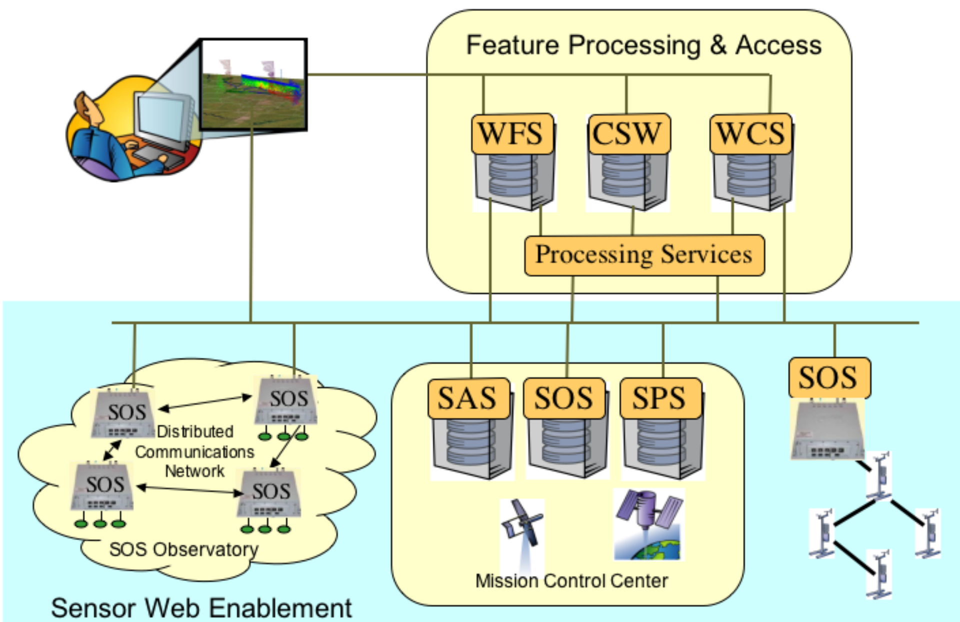


Figure 10: Enterprise SWE Geo-Processing Workflow

4.2.6.7 Access to and Processing of Predictive Models

The aim of this task area in GPW is to investigate and implement various binary grid processing methods using subsets of data that can be extracted from predictive model results as well as for final portrayal of data. To meet this goal, participants may provide/suggest models of interest that are available to evaluate the suitability of use with OGC's WPS, WCS and WCPS for filtering, processing and portraying the model results (including slices by height or by time), and to identify any enhancements to the specs to meet the desired objectives.

A demonstration scenario, illustrated by the diagram below, was performed in OWS-4 focused on earth observations with the objective of processing imagery.

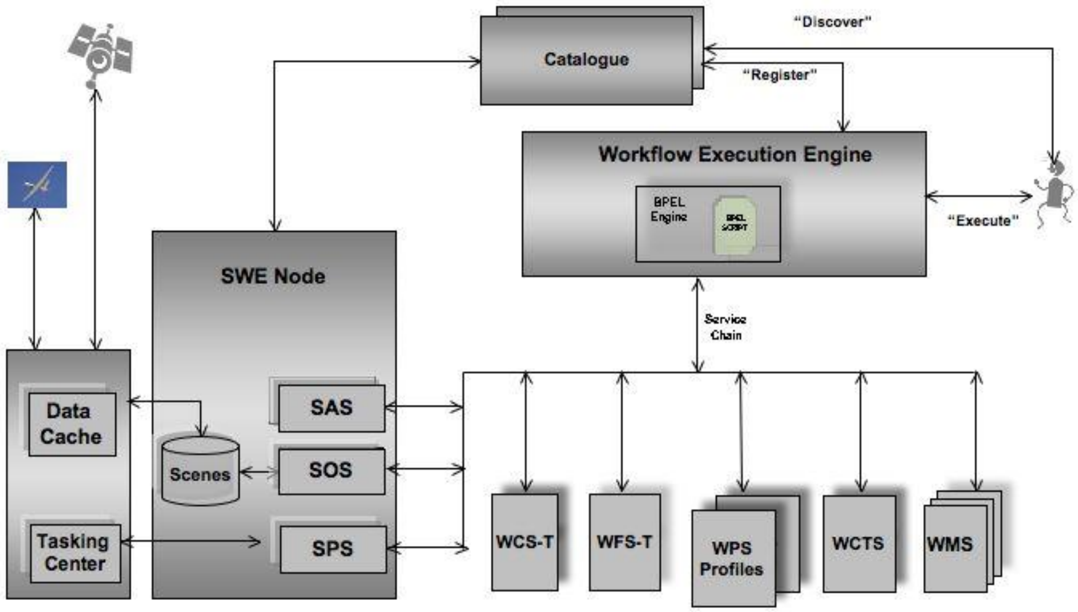


Figure 11: Components and services in the OWS-4 Earth Observation Demo

(Ref: WPS IPR - Discussions, findings, and use of WPS in OWS-4 (OGC 06-182r1))

This scenario provides a foundation upon which to build as work continues to enhance OGC services being integrated in a workflow to perform similar binary grid processing.

As a continuation of this work, participants should consider implementing more involved BPEL workflow using WPS's to process image data through a WCTS before sending to the binary processing service.

4.2.6.8 Data Fusion based on Conflation Rules

A Data Fusion Service, based on WFS and WPS that uses conflation rules to complement and refine the data fusion process is part of GPW. The Data Fusion Service and capabilities should be integrated with the workflow.

Conflation capabilities to be considered in this effort include

- pre-processing (transformation of schema, projection, datum, topology quality assessment, generalization or geometry simplification)
- feature matching criteria and methods
- preconfliction (merge schemas, integrate features, edge matching, etc)
- imagery search and retrieve and image matching

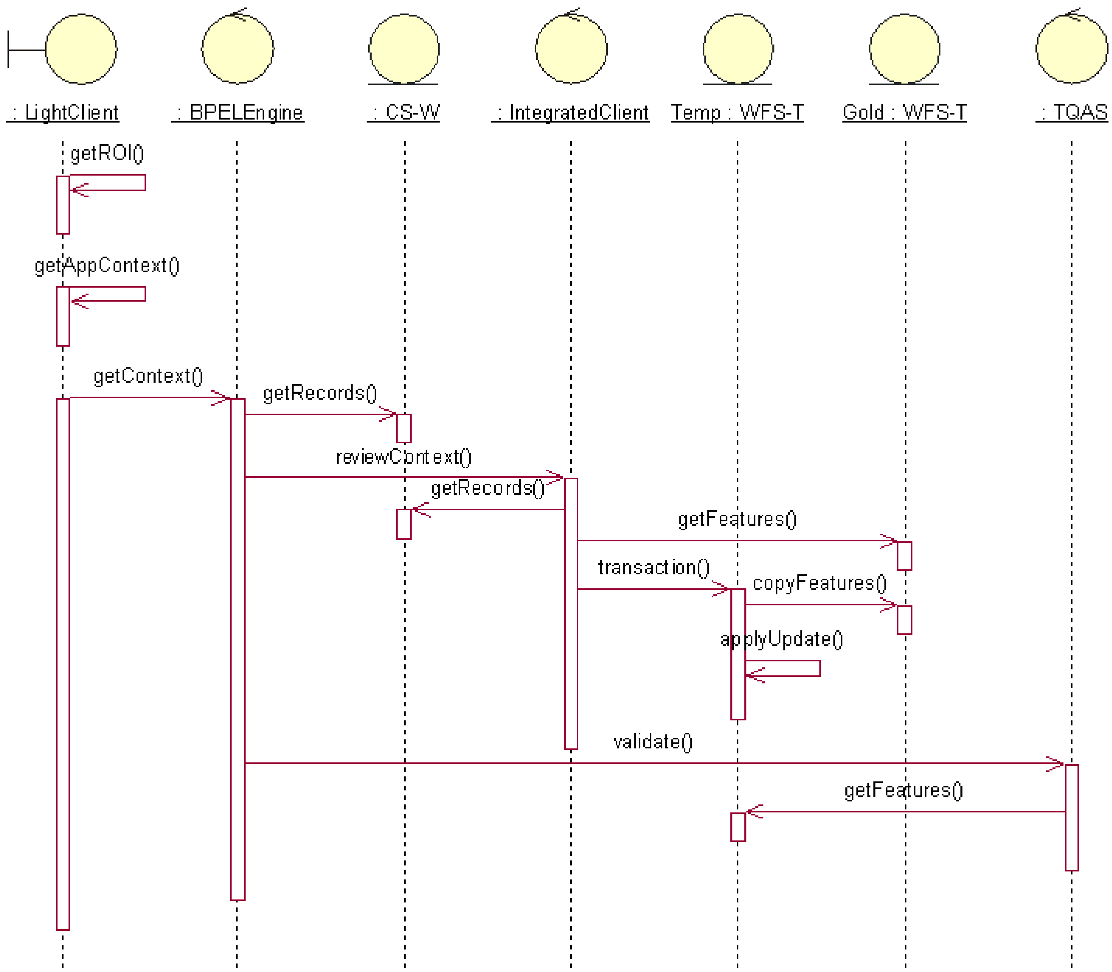
4.2.6.9 GeoRSS

GeoRSS for use with entities within a Feature Catalog that have no geometry, some of which use the geometry of other entities is a resource for GPW. Use in GPW of GeoRSS within GML as a potential solution to encoding this type of information (i.e. reports, pictures, names, boundaries).

4.2.6.10 OWS Context in the Workflow

OWS Context is a part of workflow leading to formalizing this definition as a candidate specification or as a change or enhancement to the existing Web Map Context. For this task, the workflow process should gather sources using a combination of OGC web services including WFS, WMS and others using open source data, GML data and imagery. The OWS Context shall identify and publish collected sources via the workflow for sharing and collaboration elsewhere in the workflow process. A BPEL workflow describing the creation of the OWS Context document creation and notification should be produced.

The process to create an OGC Context document for a collection of data needed for sharing and collaboration is depicted in the sequence diagram below. This diagram represents work that was planned but not implemented in OWS-4. Participants may use this diagram as an example or starting point for developing a process to be used in this testbed.



(Ref: Workflow descriptions and lessons learned IPR (OGC 06-187r1)

Figure 12: Sequence Diagram to build OWS Context in the workflow

Implement and use OWS Context documents for sharing and collaboration among clients and services in the workflow (performed in collaboration with Agile Geography thread which will refine and formalize OWS Context architecture and information modeling).

4.2.6.11 GeoRM in the Workflow

Geospatial Rights Management (GeoRM) is defined in the OGC GeoDRM Reference Model as the packaging, distributing, controlling and tracking of geospatial content based on rights and licensing information. More generally it can be taken to cover a broad spectrum of capabilities and underlying technologies supporting description, identification, trading, protecting monitoring and tracking of all forms of rights usages for both tangible and intangible (electronic) assets, including the management of rights-holders relationships.

For the purpose of this initiative, GeoRM will focus on extending and enhancing standards, technologies, and practices which enable interoperable trading of geospatial content using trust relationships to be implemented in a workflow environment using OGC web services. Trust focuses on control of access to services and includes authentication of actor identities and authorization of interactions.

4.2.7 GPW Engineering Viewpoint

This Engineering Viewpoint contains information on how services from the computational viewpoint are implemented. The component types interact based upon the services identified in the Computational Viewpoint. Figure 13 provides a summary of the component types organized consistent with a three-tier model.

- User Interfaces - The top tier is the only one with which clients (people or systems) deal directly. It provides the interfaces to describe and use the services offered;

- Business Processes - The middle tier embodies all the business processes required to respond to requests issued by clients. The services in general embody everything from authentication to complex geoprocessing on sets of data from various repositories and from generation of map views to statistical charts that the client gets back at the end of the process;

- Data Access - The lower tier provides read and/or write access to data, whether its geospatial data, accounting records, or catalogue entries stored in any of a dozen different types of registries.

To limit the complexity of the diagram, interactions between components is not made explicit in Figure 13.

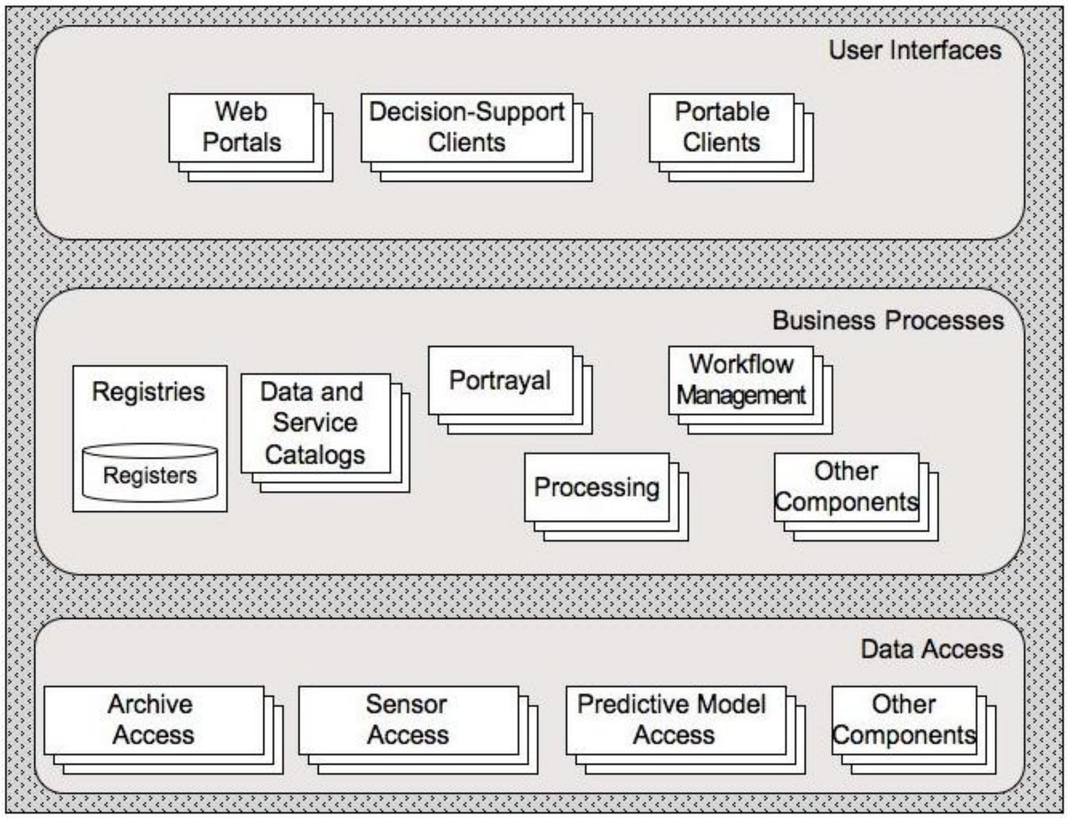


Figure 13: Engineering Viewpoint Components

An example workflow using the components is shown in the next figure:

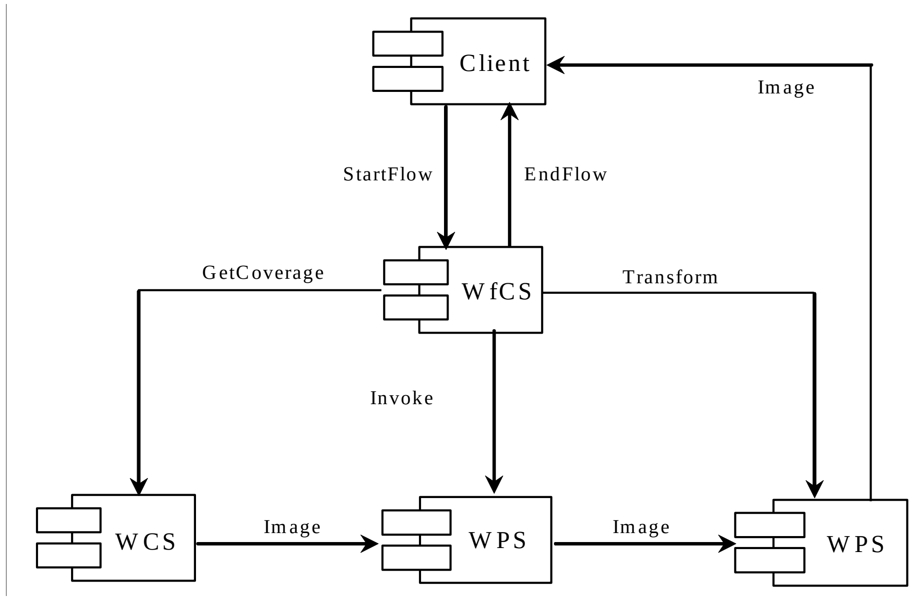


Figure 14: Example Geo-Processing Workflow

4.3 Information Communities and Semantics (ICS)

4.3.1 ICS Scope

In OWS-5, the ICS thread seeks to advance the understanding and use of complex geographic information types within an interoperability architecture. A variety of geospatial data types will be modeled in UML and converted into GML using the UGAS ShapeChange tool. Information about these data and the services provisioning them will be registered in a number of catalogs and utilized in workflows developed in the GPW thread.

This activity will test the ability of OGC standards to facilitate one of the core scenarios in any spatial data infrastructure—information publication.

4.3.1.1 UML and GML 3.2 application schema and instance document development

Prior testbeds of OWS-3 and OWS-4 established and enhanced the development and tailoring process for the application schema. These testbeds have completed the following tasks:

- Metadata describing agency application schemas to support discovery and assessment using CS-W 2.0.x services based on the ebXML Registry Information Model.

- Creation of ISO 19109 Application Schemas in UML for feature catalogues (including most recently from U.S. National System for Geospatial-Intelligence (NSG) GEOINT Structure Implementation Profile (GSIP))

- Derivation of the GML Application Schemas for application schemas using the ShapeChange UML-to-GML-Application-Schema (UGAS) conversion tool.

During OWS-5, these work items will be applied to additional types of features and datasets. This group of work items is intended to test the feasibility of GML application schemas based on OGC's Geography Markup Language Version 3.2.1 (GML3) to encode the following data types and to serve as a transfer format:

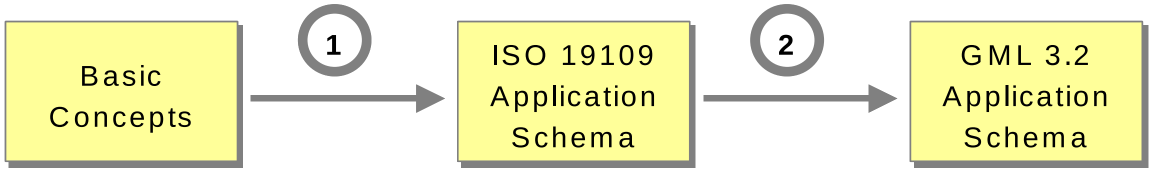
  - National System for Geospatial Intelligence (NSG) Application Schema (NAS) versions 1.8 and 2.0

  - Local Mission Specific Data (MSD)

  - Gridded coverage data based on Elevation Surface Model content of NAS draft version 2.0 (GFI - Digital Terrain Elevation Data (DTED) level 0).

All instance documents created in this thread shall include an associated ISO TC/211-19139 encoding of "dataset" level metadata.

In addition to developing GML and UML application schemas and GML instance, this task will develop mapping tables and/or procedures for mapping the data types listed above. This task will use this basic process:



The first step is executed using a Visual Basic application to create a Rational Rose UML model.

The second step is executed using the Open Source UML to GML Application Schema Tool (UGAS) tool "ShapeChange" developed by interactive instruments (ii). More information about the tool including documentation can be found at http://www.interactive-instruments.de/ugas/. The tool documentation includes one document describing the mapping rules from UML to GML as implemented by the tool plus a second document describing the implementation of the ShapeChange tool, its installation, and guidelines for using the tool.

In order to meet the end requirements for the GML application schemas and "dataset" level metadata identified above, and based upon previous experience, the following enhancements to UGAS are required:

1. Enhance UGAS to utilize OCL constraints (or at least a limited set of OCL Constraint patterns) asserted in application schemas. In application schemas these constraints are currently used either to constrain the allowed types of geometry for a Feature Type or to constrain the domain members of an attribute inherited from a superclass. Ideally, these constraints should be reflected in the resulting GML-based schema, else in a co-generated document likely to be in Schematron (for use in testing GML instance documents for schema conformance). This work should at least result in detailed design if not prototype initial capability. If Schematron is used then, UGAS would be a pass-through of Schematron assertions to produce the application schema. If UGAS can directly produce the GML, then more work would be required. Note that ISO 19136 (GML 3.2.1) clause E.2.1.1.6 OCL "Constraints" states:

   "All OCL constraints are ignored. The assessment of the validity of the instance model with respect to these constraints is the task of the application processing the GML instances"

   NOTE: The Schematron language may be used to express OCL constraints as part of the XML Schema representing the GML application schema.

2. Enhance UGAS to generate ISO 19139-conformant metadata schema from GSIP-specified UML schema that is derived in a conformant manner from ISO 19115:2006. As a minimum UGAS enhancements should be able to use Metadata Application Schema Profile in UML and generate an ISO 19139-conformant GML-based (or GML-associated/acceptable) encoding automatically.

3. This task will use a variety of Dictionaries that will be provided by the sponsoring organizations. These will be available for use/harvesting in OWS-5. UGAS may need additional enhancements to use UoM and CRS Dictionary.

4. Enhance UGAS to handle application schemas that use CV_Coverage. This effort should at least demonstrate use of what it does support with primary focus on regularly-gridded data, for 'elevation surface profile' as well as relevant aspects of BAGs (depth plus error-estimates).

5. Further enhance the processing of MSD-prototype data into GML and evaluate its use in WFS. This effort should actually process a significant set of data (thousands of features) into a GSIP-conformant instance document and then access the data using WFS.

6. Demonstrate that the open source GML-aware browser developed in OWS-4 works with GSIP-conformant data.

7. Test and demonstrate that metadata produced by UGAS can be harvested by CS/W. Identify enhancements, if needed, to UGAS as a result of the testing and demonstration.

In addition to continuing the work described above, this task should:

- Post all application schemas to OGC Network and DGIWG Portal

This task must build on the work accomplishments of previous testbeds including Schema Tailoring and Maintenance (OWS-3 GeoDSS IPR) (OGC Doc 05-117) and OWS-4 GSIP Schema Processing IPR (OGC Doc 07-028).

4.3.1.2 Cataloging and search for data and services

This task involves the registration and use of the GML application schema and instance documents described above in catalogs conforming to the CS/W 2.0.2 specification. These catalogs shall use an ebRIM profile of ISO 19115 to accomplish this task. At least two catalogs will be developed, as a key requirement of this thread is to demonstrate the ability to harvest information across catalog instances. Additionally, if these data are available through Web Feature Services or Web Coverage Services implemented in other OWS-5 threads, these services shall be cataloged as well. Specific requirements on these catalogs are below:

- Register data (Local MSD and DTED Level 0 provided as GFI), application schemas and associated dictionaries (Units of Measure, CRS, etc.) for discovery based on the applicable metadata encoding either DDMS or ISO 19139.

- Register data views. Data views will define the features and attribute content for a particular view (i.e. transportation).

- Catalog shall be capable of discovery of data content registered on other catalogs. For example, in order to satisfy a request for Local MSD, the feature data may be registered on separate catalogs—one for hydrography, one for aeronautical, and one for land features.

4.3.2 ICS Requirements

1)	Geographic Information Encoding	
	a)	Generate GML 3.2.1 application schemas for the NSG Application Schema (NAS) version 1.8.
	b)	Generate GML 3.2.1 application schemas for the NSG Application Schema (NAS) draft version 2.0.
2)	Update OWS4 Local MSD Application Schema and documentation based on changes made to the latest version of the NSG Application Schema (NAS).	
	a)	Create GML 3.2.1 instance document for prototype Local MSD (GFI provided as Shapefiles) utilizing the application schema identified above. This instance document shall include an associated ISO TC/211-19139 encoding of "dataset" level metadata.
	b)	Create GML 3.2.1 Application Schema to encode gridded coverage data based on Elevation Surface Model content of NAS draft version 2.0 (GFI - Digital Terrain Elevation Data (DTED) level 0).
	c)	Create GML 3.2.1 instance document for gridded coverage content utilizing the application schema identified above and the GFI provided. This instance document shall include an

associated ISO TC/211-19139 encoding of “dataset” level metadata.
d) Cataloging and Search
e) CS-W 2.0.2 ebRIM ISO 19115 profile
i) Register the data (Local MSD and DTED Level 0 provided as GFI), the application schemas and associated dictionaries (Units of Measure, CRS, etc.) for discovery based on the applicable metadata encoding — either DDMS or ISO 19139.
ii) Register data views. Data views will define the features and attribute content for a particular view (i.e. transportation).
iii) Discover data content registered on other catalogs. For example, in order to satisfy a request for Local MSD the feature data may be registered on separate catalogs — one for hydrography, one for aeronautical, and one for land features.
iv) UGAS ShapeChange enhancements
f) Automate generation of ISO 19139-conformant metadata schema from the NAS draft version 2.0.
3) Enhance ShapeChange to utilize Object Constraint Language (OCL). Schematron constraints shall be considered for “additional capability” as asserted in the NAS draft version 2.0.
4) Handle application schemas that use CV_Coverage.
5) Use “dictionaries” such as Units of Measure dictionary.

Table 3– ICS Requirements

4.3.3 ICS Deliverables

The following Interoperability Program Reports (IPRs) will be developed in the ICS thread and submitted to the OGC Specification Program at the completion of the OWS-5 Testbed.

1) Local MSD Implementation Profile IPR
2) Data View Architecture IPR
3) GEOINT NAS Schema Processing IPR

Implementations of the following services, tools and data instances will be developed in this OWS-5 thread, tested in Technology Integration Experiments (TIEs) and invoked for cross-thread scenarios for OWS-5 demonstration events:

1) GML 3.2.1 application schemas - NAS V1.8
2) GML 3.2.1 application schemas - NAS V2.0
3) GML 3.2.1 application schemas – Local MSD
4) GML 3.2.1 application schemas - grid coverage DTED
5) GML 3.2.1 instance documents - Local MSD
6) GML 3.2.1 instance documents - grid coverage
7) Enhanced UML-GML Application Schema tool
8) OGC Catalog 2.0.2 (ebRIM profile of ISO 19115)
9) Web Feature Service: GML 3.2.1 Local MSD

10) Web Coverage Service: grid coverage DTED data

4.3.4 ICS Enterprise Viewpoint

Fundamental to any service oriented enterprise is the ability to discover resources. This requires that the enterprise provide a limited number of well–known services where any type of resource can be discovered. It also requires that the information used to discover resources be present, understandable, and accurate. The services and techniques used should be the same regardless of whether the service is part of a portal architecture or if it is a stand-alone service.

4.3.4.1 ICS Use Cases

4.3.4.1.1 Use Case #1: Geographic Information Publication

Use Case Identifier: ICS #1	Use Case Name: Geographic Information Publication
Use Case Domain: OWS-5 ICS Publish	Status:
Use Case Description: This use case describes the process of modeling geographic data in UML, translating that model into GML, creating GML instance documents based on that model, and publishing both the model and instance documents in a catalog.	
Actors (Initiators): Data custodian	Actors (Receivers): Catalog service
Pre-Conditions: - Initiator has data - Initiator has GML competency - Initiator is proficient with UGAS tool - Initiator has write access to catalog service	Post-Conditions: - GML application schemas created - GML instance documents created - Both published to catalog
System Components - UGAS ShapeChange tool - CS-W: Catalog Service Web Profile - XML editing software	
Basic Course of Action: 1. User develops UML models for data sets 2. User exercises UGAS tool on the UML models 3. User processes data from native format into GML 4. Users publishes UML, GML schema and GML instance documents to catalog	

4.3.4.1.2

4.3.4.1.3 Use Case #2: Information Search via CS-W

Use Case Identifier: ICS #2	Use Case Name: Geographic Information Search
Use Case Domain: OWS-5 ICS Search	Status:
Use Case Description: Enable data types, schemas, dictionaries, etc., to be discovered from a catalog	
Actors (Initiators): User	Actors (Receivers): User
Pre-Conditions: - User has catalog client software - User needs to find a particular type of data set	Post-Conditions: - Resources have been discovered
System Components - CS-W client - CS-W service	
Basic Course of Action: 1. User chooses the type of information to query (keyword, category, schema, etc.) 2. User enters query terms 3. CS-W returns results 4. User refines query based upon results	

4.3.4.1.4 Use Case #3: Cross-Catalog Harvesting

Use Case Identifier: ICS #3	Use Case Name: Geographic Information Harvesting
Use Case Domain: OWS-5 ICS Harvesting	Status:
Use Case Description: Enable data types, schemas, dictionaries, etc., to be harvested across catalogs	
Actors (Initiators): CS-W service	Actors (Receivers): CS-W service
Pre-Conditions: - 2 or more CS-W services with a combination of overlapping and non-overlapping resources	Post-Conditions: - All catalogs contain the same information
System Components - CS-W services	

Basic Course of Action:

1. Each catalog is stood up with data, ideally representing a data type like water, transportation, etc.
2. Catalogs are informed of each other's existence
3. Catalogs harvest data from each other

4.3.5 ICS Information Viewpoint

4.3.5.1 Digital Terrain Elevation Data (DTED) level 0

Relevant Specifications:

- Performance Specification Digital Terrain Elevation Data (DTED) (http://www.nga.mil/ast/fm/acq/89020B.pdf)

DTED is a uniform matrix of terrain elevation values which provides basic quantitative data for systems and applications that require terrain elevation, slope, and/or surface roughness information. DTED Level 0 elevation post spacing is 30 arc second (nominally one kilometer). DTED0 was derived from NIMA DTED Level 1 to support a federal agency requirement.

4.3.5.2 GML Application Schema development

Relevant Specifications:

- Geography Markup Language (GML) v3.2.1 (OGC 07-036)
- GEOINT Structure Implementation Profile Schema Processing IPR (07-028)
- Schema Tailoring and Maintenance (OWS-3 GeoDSS IPR) (05-117)

4.3.5.3 GML 3.2

Relevant Specifications*:*

- OpenGIS® Geography Markup Language (GML) Encoding Specification 3.2.1 (OGC pending 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.

4.3.5.4 GML in JPEG 2000 for Geographic Imagery Encoding Specification (GMLJP2)

Relevant Specifications:

- OpenGIS® GML in JPEG 2000 for Geographic Imagery Encoding Specification version 1.0.0 (OGC document #05-047r3) (http://www.opengeospatial.org/standards/gmljp2)

The GML (Geography Markup Language) is an XML grammar for the encoding geographic information including geographic features, coverages, observations, topology, geometry, coordinate reference systems, units of measure, time, and value objects. JPEG 2000 is a wavelet based encoding for imagery that provides the ability to include XML data for description of the image within the JPEG 2000 data file. This specification defines the means by which GML is to be used within JPEG 2000 images for geographic imagery. This includes the following:

- Specification of the uses of GML within JPEG 2000 data files.
- Packaging mechanisms for including GML within JPEG 2000 data files.
- Specific GML application schemas to support the encoding of OGC coverages within JPEG 2000 data files.

4.3.6 ICS Computational Viewpoint

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

4.3.6.1 Catalog ebRIM Profile

Relevant Documents:

- OGC Catalogue Service v2.0.2 (07-006r1)
- ISO Metadata using ebRIM Profile Discussion Paper (07-038)
- ISO 19115 Geographic information — Metadata
- CSW-ebRIM Modeling Guidelines Discussion Paper (06-155)
- OGC ebRIM Profile of CS-W (05-025r3)

The OGC Catalogue Services v2.0.2 specification (OGC 07-006r1) establishes a framework for implementing catalogue services that can meet the needs of stakeholders in a wide variety of application domains. This application profile is based on ebXML ebRIM ISO/TS 15000-3.

4.3.6.2 Web Coverage Service

Relevant Specifications: *OpenGIS® Web Coverage Service specification v 1.1*

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.

An elevation model is a type of coverage. The role of the WCS in ICS is to provide archive and dissemination services for DTED elevation data.

4.3.6.3 Web Feature Service

Relevant Specifications: *OpenGIS® Web Feature Service version 1.1*

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. In ICS the WFS will provide feature access to Local MSD data.

4.3.6.4 UML to GML Application Schema (UGAS) Tool

Relevant Specifications: *OpenGIS® OWS-2 Application Schema Development IPR (OGC 04-100)*

The UML to GML Application Schema (UGAS) tool was originally developed as part of the GOS-TP initiative. Its' purpose is to facilitate the creation of GML Application Schemas from information models captured in UML. UGAS was applied again in the OWS-2, OWS-3 and OWS-4 testbeds. For OWS-5, UGAS will be once again used to develop GML application schemas, and also be extended to support:

OCL constraints (or at least a limited set of OCL Constraint patterns) asserted in application schemas. In application schemas these constraints are currently used either to constrain the allowed types of geometry for a Feature Type or to constrain the domain members of an attribute inherited from a superclass. Ideally, these constraints should be reflected in the resulting GML-based schema, else in a co-generated document likely to be in Schematron (for use in testing GML instance documents for schema conformance).

1. Enhance UGAS to generate ISO 19139-conformant metadata schema from GSIP-specified UML schema that is derived in a conformant manner from ISO 19115:2006.

2. Handle application schemas that use CV_Coverage. This effort should at least demonstrate use of what it does support with primary focus on regularly-gridded data, for 'elevation surface profile' as well as relevant aspects of BAGs (depth plus error-estimates).

Use a variety of Dictionaries that will be provided by the Sponsoring organizations, which may require additional enhancements to UGAS.

4.3.7 ICS 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. This viewpoint is concerned primarily with the interaction between distinct computational objects: its chief concerns are communication, computing systems, software processes and the clustering of computational functions at physical nodes of a communications network. The engineering viewpoint also provides terms for assessing the "transparency" of a system of networked components – that is, how well each piece works without detailed knowledge of the computational infrastructure.

For ICS in OWS-5, the engineering viewpoint describes the process of converting various information resources into XML, and registering them in a catalog. The catalog may then be queried, and is also capable of sharing its holdings with other catalogs.

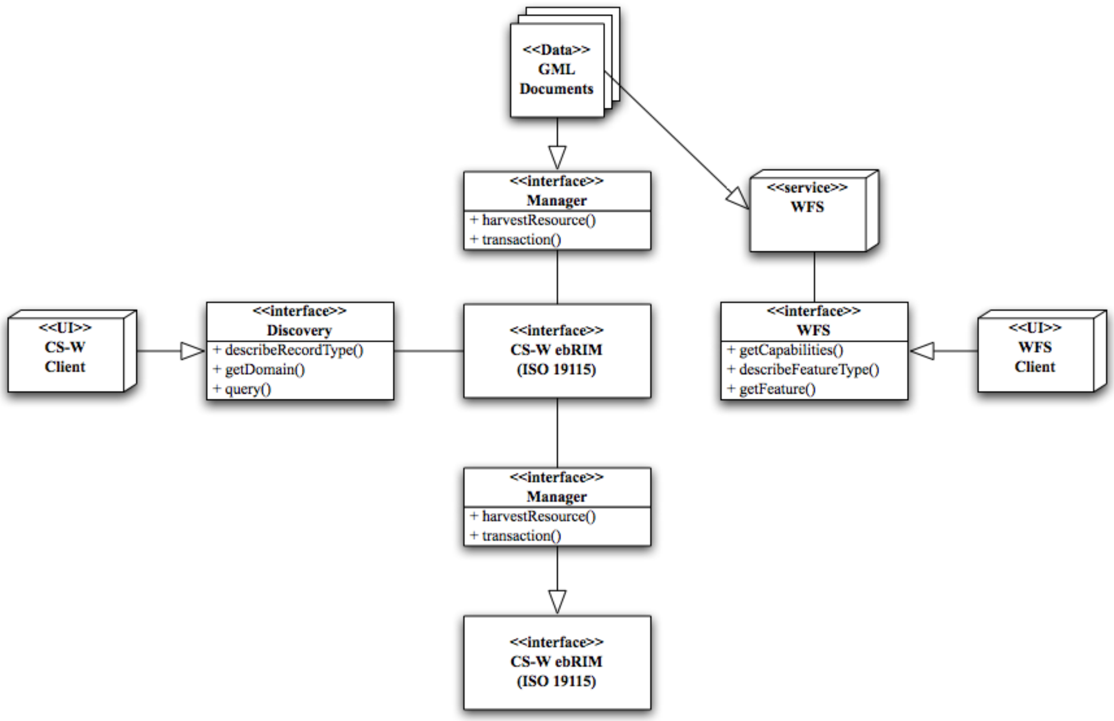


Figure 15: ICS Engineering Viewpoint

4.4 CAD/GIS/BIM (CGB)

The CGB activities in the OWS program are directed toward bridging the information models and workflows of the various communities involved with the representation of the built environment in three dimensions. Standards for interoperable exchange of information about buildings and standards for representing and exchanging information about cities at broad-scale are beginning to enable owners, administrators and toolmakers to make investments in developing assets based on these standards. Applications of integrated city models are emerging in the mass-market sphere, witness Google Earth and Microsoft Local Live. One can imagine the extension of these tools into the domains of location-based services for emergency preparedness and response. These applications will require the integration of semantically rich authoritative information that is likely to be created in a highly distributed fashion. This thread of OWS-5 focuses on developing a services-based architecture that will bring the necessary information together, and to make it accessible in a secure way.

4.4.1 CGB Scope

Activities of this thread will focus on the extension of the OGC Reference Model (ORM) to the information models and workflows of the Architecture Engineering and Construction and Facility Management industries (AEC+FM). Building on the work of OWS-4 completed in 2006, we will develop geospatial views of Building Information Models (BIM). These will be very simple subsets of BIM oriented toward integration with information about their greater context in the city. Participants in this thread will develop applications of Web Feature Services for BIM (WFS-BIM). This service architecture provides access to BIM features through open web interfaces. The service architecture will be further developed to facilitate the discovery of information from distributed BIM using Catalog Services for the Web (CS/W). This focus will return a quick understanding and exploitation of some of the most valuable cross-community applications of BIM and City Models in the areas of:

- Emergency Preparedness and Response
- Management and Planning of Campuses, Cities or Military Installations
- Commercial Location-Based Services.

The focus on relatively simple geospatial views of BIM will provide participants in this initiative with an opportunity to develop pilot systems respecting the new and emerging industry standards including the U.S. National BIM Standard (NBIMS): OmniClass and International Framework for Dictionaries (IFD), and City Geographic Markup Language (CityGML) and Industry Foundation Classes Extended for Geospatial (IFC2x3g.) This work will provide rapid, early feedback on the applicability of these standards in terms of their implementation and interoperability.

Tangible products will include

- Documentation of best practices for creating BIM Model Views incorporating IFD or OmniClass taxonomies.
- Demonstrations of working applications and Interoperability Program Reports (IPR) documenting technical issues encountered and
- A roadmap for the co-evolution of the information models, workflows and technical components of the AEC+FM and Geospatial communities.

The NBIMS initiative reflects that progress toward applications of interoperability of BIM requires the development of Information Delivery Manuals (IDM) documenting information needs for domain-specific applications. In practice, development of IDMs will involve intensive collaboration among subject-matter experts. In OWS-5, the focus will be on the development of the machinery for creating and using very simple pilot IDMs in order that we can quickly observe the issues and applications of services-based interoperability of BIM from end to end.

4.4.2 CGB Requirements

1) Information Delivery Manuals for Geospatial Applications (NBIMS and CityGML)
a) Building Model Identifiers for Catalog Registry and Discovery
b) Information Assurance (Digital Rights Management)
c) Building Indoor Location Referencing by Identifier
d) Critical Locations for First Responders
e) Space Planning and Assessment
f) Building Levels of Detail
g) IDM for CityGML Applications for LEED Neighborhood Development
h) IDM for CityGML Emergency Preparedness
i) IDM for CityGML Space Planning and Assessment
2) Capabilities in Web Feature Services for BIM and CityGML

	a) Support for OWS-5 MVDs
	b) Translation of BIM Coordinate referencing systems (CRS) to geospatial CRS
	c) Filter Encoding / Query of BIM and CityModel features by location
	d) Filter Encoding / Query of BIM and CityModel features based on IFD semantics
	e) Filter Encoding / Query of BIM and CityModel Features based on references to building indoor locations
	f) Delivery BIM features in CityGML format for OWS-5 IDMs
	g) Publish metadata about Building and City Models based on Identification MVD
	h) Prototype information assurance through the use of GeoDRM gateway and feature-level access constraints passed in IA Model View Definition.
	i) Publish Feature-type metadata based on IFD or OmniClass semantics
	j) Facilitate update of BIM feature properties through web interface.
3)	**Catalog Services for the Web Capabilities**
	a) Return appropriate information regarding Building and City Model Features based on Omniclass or IFD Semantics.
	b) Respect Digital Rights Management constraints for Catalog Access
4)	**CGB Client Capabilities**
	a) Tools for authoring BIM according to the OWS-5 IDMs.
	b) Modules for translating OWS-5 IFC Model Views Definition to CityGML.
	c) Viewing client capabilities for visualizing CityGML buildings in the context of georeferenced context information.
	d) Clients for indoor location-based services capable of developing requests to WFS for BIM based on information gathered from environment.
	e) Analytical tools incorporating information from the neighborhood analyses IDM in cityGML for the analysis of neighborhood impacts of construction operations or other situations..
	f) Authoring tools for developing CityGML CityModels or compatible schema.
5)	**Client-Server Interaction**
	a) Digital Rights Management (Information Assurance) based on user privileges and feature properties

b) Update of BIM Feature Attributes through Xlinks from CityGML

Table 4 – CGB Requirements

4.4.3 CGB Deliverables

The following Interoperability Program Reports (IPRs) may be developed in the CGB thread and submitted to the OGC Specification Program at the completion of the OWS-5 Testbed.

1)	Roadmap for integration of AEC+FM information models and Geospatial Information Infrastructure IPR
2)	Transactional Web Feature Services for BIM IPR
3)	Catalog/Registry Requirements for BIM and CityModel Features IPR
4)	Best practices for developing IDM and MVDs for IFC and CityGML
5)	Georeferencing BIM with IFC2x3G in Web Services IPR
6)	IFC IDMs and MVDs for CityGML IPR
7)	IFC IDM/MVD for Space Planning and Assessment IPR
8)	IFC IDM/MVD for First Responders IPR
9)	IFC IDM/MVD for Indoor Location Services IPR
10)	CityGML IDM/MVD for Emergency Preparedness IPR
11)	CityGML IDM/MVD for LEED Neighborhood Development Rating IPR
12)	CityGML IDM/MVD for Space Planning / Space Assessment IPR
13)	Implementation of Geospatial IDMs and MVDs in CAD Authoring Tools IPR
14)	Mediation of Indoor Location by Identifiers and Geospatial Coordinates IPR
15)	CityGML Development in GIS IPR
16)	GeoDRM for BIM IPR
17)	Integration of CityModels with GIS IPR

Implementations of the following services, tools and data instances will be developed in this OWS-5 thread, tested in Technology Integration Experiments (TIEs) and invoked for cross-thread scenarios for OWS-5 demonstration events:

1)	Integration of WFS-T for BIM with Clients via GeoDRM Gateway
2)	Integration of WFS for BIM with CS/W through automated harvest
3)	Integration of WFS for BIM with CS/W through active publishing
4)	Integration of Lightweight 3D GML Viewing Client with WFS-T for BIM
5)	Integration of Lightweight 3D GML Viewing Client with LBS Tracking Service
6)	Integration with GIS Analysis and Data Development Client with WFS through CityGML
7)	Integration of CAD/BIM Editing Clients with NBIMS Information delivery Manuals, and IFC Model Views

8) Integration of IFC to CityGML Conversion modules within BIM Authoring or WFS-BIM components

4.4.4 CGB Enterprise Viewpoint

Information about the built environment (buildings, transportation, utilities, and other physical infrastructure) and their surroundings is emerging from many domains. The surveying and photogrammetry community are developing broad-scale, wholesale three-dimensional models of cities; architects and engineers are developing very detailed infrastructure models, and ordinary citizens are using free tools to create and share models of their neighborhoods. Fixed and mobile sensors of many kinds are providing dynamic data and emerging location-based services. There are many types of documents or data objects that might be referenced to places inside buildings (such as Evacuation Plans or Inventories of Hazardous Materials that would be useful to be able to discover and access based on references to indoor locations.

Though these information and infrastructure development activities are being planned and conducted largely independently of one another, there are many applications that would multiply the value of these information assets if they could be combined. A Service Oriented Architecture, based on the OGC Reference Model (OGC-RM) can integrate information from all of these streams so that they may interoperate and serve multiple purposes from emergency response, to neighborhood planning, and commercial location-based services.

Web services and clients developed in OWS-4 demonstrated that it is not necessary to completely harmonize or assimilate diverse information schemes in order to have the advantages of spatial discovery and interoperability provided by the OGC RM. By adding OGC Web Feature Service interfaces to an existing BIM server, site-specific Building Information Models became discoverable through OGC Catalog services, and were interoperable at a feature-level with City Models developed for broad-scale analysis and administration. In this case, the OGC architecture acts as a bridge between the AEC and geospatial information domains. In OWS-5 we will extend this bridging potential of Web Feature Services and Catalog Services to create a common infrastructure for referencing a variety of information streams related to the built environment.

4.4.4.1 The National Building Information Model Standard

The National Building Model Standard (NBIMS), published as a review draft in March 2007 by the National Institute of Building Sciences (NIBS), holds a promise to create a standardized stream of data related to buildings[1]. The NBIMS provides a protocol for developing Information Delivery Manuals (IDM) that specify information exchange requirements in such a way that the buyer may have a guarantee that information delivered will interoperate as expected. IDMs will permit investments to be made in tools and services with assurances that the applications may be developed and supported by multiple vendors[2]. We can expect that the NBIMS will at first result in some fraction of new construction being documented in such a way as to be compatible with BIM servers. More importantly, this standard will lead to the development of BIM authoring tools that are based on the expectations set out in IDMs. The widespread adoption of simple IDM and authoring tools that can write to them will facilitate and encourage the development of BIM for high value applications such as space planning within existing buildings. Once

[1] See: http://www.facilityinformationcouncil.org/bim/publications.php

[2] National Building Information Modeling Standard (NBIMS) Version 1.0 – Part 1: Overview, Principles, and Methodology, Section 5.

these BIM exist, they will serve as a framework for other useful bits of information infrastructure related to buildings, such as location-based services and integration with larger city models.

Figure 16 below from the NBIMS 1.0 provides an overview its structure.

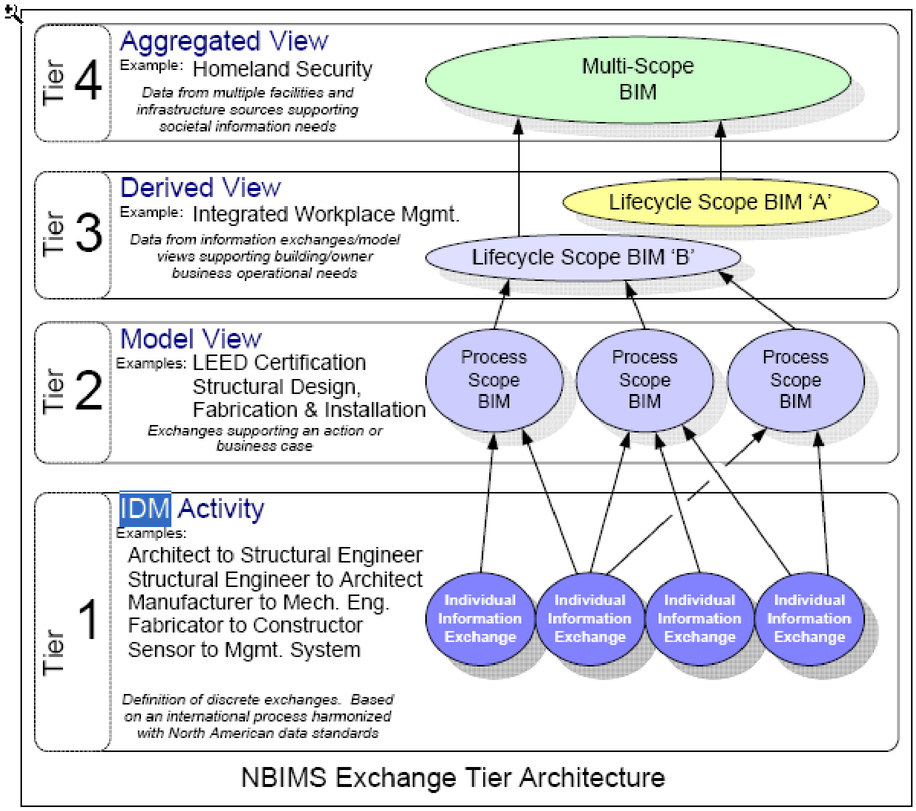


Figure 16: NBIMS Exchange Tier Architecture (NBIMS 2007)

4.4.4.2 OWS-5 Model View Definition Prototypes

The plan for OWS-5 includes the development and application of the following Information Delivery Manual prototypes. IDMs are a human readable means of specifying a set of BIM concepts. These are implemented by specific software applications and corresponding web services and exchanged as IFC Model View Definitions (MVD). These MVDs will be developed for the purposes of developing and testing the principles and behaviors of software components. In practice, the development of IDMs will involve intensive collaboration and consensus among subject matter experts. Our intention in this testbed is to quickly develop simple pilot IDMs so that we can quickly understand the process of their development and their application in interoperable web services architecture from end-to-end. Although we have chosen to avoid complex model views for applications such as building code checking or energy assessment, the simple geospatial model views developed will support very high value applications.

The specific information delivery manuals developed here are intended to define the information elements necessary for identifying buildings themselves for purposes of cataloging and discovering building model assets. A general IDM for identifying locations within buildings will define simple information concepts for identifying indoor places in a very general sense, and two more specific model views will articulate place information in terms of properties of concern for space planning and assessment, for first responders;. The model views for representation of buildings at multiple levels of detail will provide a context for understanding the relationships of these indoor locations with the gross physical structure of the building. In order to support secure access to this information, we will define a simple IDM regarding information access constraints for specific model features. The specific IDMs and MVDs that may be developed in this activity are listed below:

1. Building Model Identifiers (metadata for cataloging building models)
2. Building Indoor Location Referencing by Identifier
3. Critical Locations for First Responders
4. Space Planning and Assessment
5. Building Representation at Levels of Detail (see Figure below for example)
6. Information Assurance (Digital Rights Management)

These IDMs are highly related and may be seen as rolling up, with the higher level of detail IDM incorporating the concepts from the IDMs that occur earlier in the list.

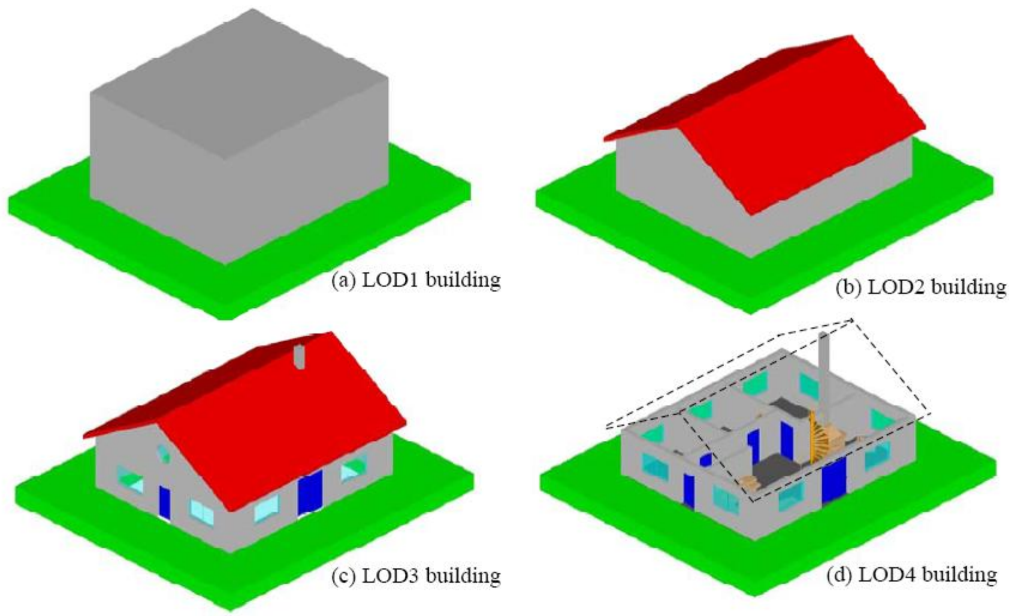


Figure 17: Building Levels of Detail in CityGML

4.4.4.3 Integration of BIM with Web Services Architecture

OWS-4 demonstrated the interfaces of OGC Web Feature Services (WFS) and Catalog Services for the Web (CS/W) provide a bridge between the world of BIM and the world of geospatial web services. These interfaces add important capabilities for discovering information distributed over servers at many locations, and allowing users to interoperate using features from BIM along with other information related to the greater world. In OWS-5 we will extend these capabilities to incorporate the OWS-5 MVDs, and develop metadata interfaces for registering features from these MVDs with catalog services. These metadata exchanges will be guided by the taxonomic principles and the constrained vocabulary provided in the International Framework for Dictionaries (IFD) and OmniClass – both specified as naming conventions for features within NBIMS.

Any web services architecture for handling administrative data such as BIM should have a strong means of assuring that only users with appropriate privileges are able to access or update information on the server. The NBIM standard refers to this necessity as Information Assurance (NBIMS Chapter 3.4). In the OGC architecture this same notion is referred to as GeoDigital Rights Management. OWS-4 saw the development of gateway components that can stand between users and the WFS in order to assure controlled access to specific features[3]. Developers of WFS for BIM servers in OWS-5 may develop these GeoDRM capabilities further by handling information catalog and feature access based on information provided in the Information Assurance IDM.

Specific features of WFS for BIM that may be developed in OWS-5:

1. Support for OWS-5 MVDs
2. Translation of BIM Coordinate referencing systems (CRS) to geospatial CRS
3. Filter Encoding / Query of BIM features by location
4. Filter Encoding / Query of BIM features based on IFD semantics
5. Filter Encoding / Query of BIM Features based on references to building indoor locations
6. Delivery BIM features in CityGML format for OWS-5 IDMs
7. Publish metadata about Building Models based on Identification MVD
8. Prototype information assurance through the use of GeoDRM gateway and feature-level access constraints passed in IA Model View Definition.
9. Publish Feature-type metadata based on IFD or OmniClass

4.4.4.4 Development and Applications of City Models

Building Information Models are oriented toward specific buildings or sites but applications such as emergency response or impact assessment do not end tat the site boundary for a building Three-dimensional City Models provide a framework for integrating building models within the context of their overall environment. In this testbed we will continue the work, begun in OWS-4 to integrate the information models for BIM with the greater context,. Broad scale city models are becoming more common through a convergence of improved methods for developing them, for structuring and exchange and for delivering, visualizing and analyzing city models. The development of city models and the infrastructure for managing and using them will be accelerated by a widely accepted consensus-based standard analogous to the role of IFC in the AEC world. Such a standard data model for urban environments will encourage investments in data, and the development of interoperable tools for developing serving and using these models. CityGML is emerging as such a standard and is rapidly being adopted in Europe,[4] but has yet to achieve broad support in popular authoring or analytical tools. OWS-4 demonstrated that CityGML Level 4 Models (Figure 17) are useful for representing space planning and assessment information from BIM into the geospatial information infrastructure. An important theme in OWS-5 will be to build demonstrations of the use of city models in the data creation and management tools, and in common visualization analytical tools. The focus of this work will be exploitation of the

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[3] Geospatial Digital Rights Management Reference Model (geoDRM RM), Graham Vowles, Editor. OGC Pending Discussion Document, February 2006.

[4] See: http://www.citygml.org/

OWS-5 IDMs discussed in the previous section, serving this information to multipurpose catalog/discovery, viewing, analysis and authoring clients as CityGML through Web Feature Services for BIM.

As specifications such as IFC and NBIMS are making it safe to invest in interoperable tools and applications, and the development of data assets, CityGML will permit, for the first time, investments in information infrastructure for representing three dimensional cities. Particularly for the substantial amount of urban territory that is not the domain of building operators. Development of very high-value, high-cost applications such as Emergency Preparedness and environmental impact assessment are considered impractical to develop for lack of consistent source of interoperable base information concerning urban conditions. Without a consistent, stable schema for developing information resources for these applications, the cost of developing local one-off implementations is too high to justify the benefits. The notion of Information Delivery Manuals developed in NBIMS can be instructive here. We propose to develop several IDMs for city modeling, comparable with the IDMS proposed for Building Information Modeling. These IDMs will serve as a platform for subject matter experts to agree on which information assets are necessary to do their work. IDMs will also give application developers a stable and simple-as-necessary target for developing citymodel schema to support these applications.

Specific applications of integrated BIM and City Models that will be considered in OWS-5 include:

1. Tools for authoring BIM according to the OWS-5 IDMs.
2. Modules for translating OWS-5 IFC Model Views Definition to CityGML.
3. Viewing client capabilities for visualizing CityGML buildings in the context of georeferenced context information.
4. Clients for location-based services capable of developing requests to WFS for BIM based on information gathered from environment, such as landmarks tagged with passive RFIDs.
5. Analytical tools incorporating information from the LEED Core and Shell MVD for the analysis of greater spatial patterns within the Neighborhood Environmental Sustainability.
6. IDM/MVD for Location by Reference
7. IDM/MVD for Emergency Preparedness
8. IDM/MVD for Neighborhood Impact Assessment

4.4.4.4.1 Indoor and Outdoor Location-Based Services

Tracking and location-based services provide an important test and application of the integration of indoor and outdoor information models. For example, in a classic application of location based services, a pair of geographic coordinates returned by a mobile GPS, may be associated with a nearby feature (e.g. closest pizza parlor) by a process of reverse geocoding. If we would like this functionality to work inside of a shopping mall, there are a couple of problems to solve. First that GPS will not work indoors, and second, that indoor locations are not as uniformly referenced as the street addresses for buildings.

There are a number of means for providing local position information inside of buildings, augmenting the out-door GPS framework. Some of these will return geospatial coordinates (e.g. by triangulating radio signals form registered transceivers). Other architectures may provide location by reference, (e.g. the use of RFID landmarks identifying room numbers or other indoor locations) In either case, there is a need to emulate the notion geocoding in the indoor environment. This may take the form of providing a geospatial coordinate for a referenced, named location, or by providing a named indoor location based on a coordinate reference.

The capabilities of WFS for BIM and the information content defined in the OWS-5 model view definitions will allow us to prototype an architecture for seamless indoor-outdoor location based services based on any of the technologies for establishing indoor locations.

4.4.4.5 CGB Use Cases

The OWS-5 testbed may demonstrate the value of AEC+FM interoperability with City Models with two possible use-case scenarios: Location Based Services for First Responders, and neighborhood impact assessment.

4.4.4.5.1 Use Case #1: Location Services for First Responders

This scenario is based on a feasibility study published by NIST[5] concerning Indoor Navigation for First Responders. Though this use Case is emergency oriented, the components and workflows demonstrated here would be equally valid for everyday situations such as inventory management and mass-market location-based services. The RFID architecture for LBS is included here as a simple solution that makes use of WFS queries to translate directly-sensed passive indoor location identifiers to geospatial locations. This architecture is considered valuable for emergency response since it is highly stable with regard to electrical outages and other issues that may be at issue during or after an emergency. Regardless of the architecture used for location, this use-case demonstrates the value of a standards-based framework for modeling and exchanging information about indoor and outdoor locations for developing and exploiting Location Services. Depending on sponsorship and participant interest, the specific LBS instrumentation implemented in this workflow may be substituted.

<table>
<tr><td>Use Case Identifier: CGB #1</td><td colspan="2">Use Case Name: Location Services for First Responders</td></tr>
<tr><td colspan="2">Use Case Domain: OWS-5 CGB</td><td>Status: Under development. Draft 3/11/07</td></tr>
<tr><td colspan="3">Use Case Description: This use case describes the use of CGB Industry Specifications, Service Architectures and Clients for the development and deployment of Emergency Preparedness Infrastructure.</td></tr>
<tr><td colspan="2">Actors (Initiators): Emergency Preparedness Planners, Information Infrastructure Developers,</td><td>Actors (Receivers) Building Operators, Emergency First Responders</td></tr>
<tr><td colspan="2">Pre-Conditions:
- Individual BIM exist for a multi-building complex.
- BIM are available in a WFS-T for BIM</td><td>Post-Conditions:
First Responders able to locate specific features under emergency conditions, to take corrective action and to register changes to emergency command center</td></tr>
<tr><td colspan="3">System Components</td></tr>
</table>

[5] Leonard E. Miller, Indoor Navigation for First Responders - A Feasibility Study. February 2006, National Institute for Standards and Technology

- WFS-T for BIM
- WFS Serving CityGML
- CS-W: Catalog Service for the Web
- BIM Authoring Client respecting NBIMS Model View Definitions
- Lightweight GML client for 3d Visualization and Query and Update with RFID Scanner
- GeoDRM Gateway

Basic Course of Action:

1. Phase 1: Development of Infrastructure for Emergency Preparedness (Building Operator)
    a. Building Operators use a BIM authoring client to define key locations within the building and its site that may be of interest during an emergency.
    b. locations are given unique references in the MVD for first responders.
    c. The nomenclature for these locations or the activities and materials of interest are drawn from IFD or OmniClass taxonomies.
    d. Physical locations of specific landmarks in the building (including some, if not all of the locations in the IDM For First Responders) are marked with RFID tags. The unique signature for each of these is also entered into the BIM and associated with geometric features (e.g. physical mount-point and detectable range.
    e. Physical Locations outside of buildings are represented as properties of CityObjects in a CityGML model, and tagged with RFID tags in the physical world.
2. Phase 2: Evaluating Emergency Preparedness (Neighborhood/City Preparedness)
    a. For each building in the area, Model Views for Emergency Preparedness (EP) are registered with a CS/W with specific rules for restricting access to users with appropriate credentials.
    b. EP Planners test the CS/W using a lightweight GML viewer and discovery client to search for information of critical interest for first responders. Though this system is within a secure intranet, credentials must be entered to discover and view this information.
    c. Specific features are updated, registering their priority and instructions related to particular types of emergency situations at a neighborhood level
3. Phase 3: Emergency Response Drill
    a. Simulating conditions of evacuation and reduced visibility a first responder is on the site with a tablet PC equipped with a RFID scanner and a recent dump of a city model that incorporates information from the first responder's IDM.
    b. The first responder is uses pre-defined priorities to identify a fresh air intake of a building that needs to be covered.
    c. The emergency coordinator is tracking the location of the responder via GPS. As she moves close to or inside of buildings, her location transceiver establishes an indoor location, by detecting locally registered RFID, and this position is translated to geospatial coordinates through a query to a WFS for BIM on the internet and relayed back to the command center.
    d. She moves toward the location of the air intake, the computer informs her when she moves within range of the RFID landmark associated with the fresh air intake for the building
    e. The condition is attended to, and the first responder registers a change to the On-Line BIM, which is monitored by the emergency coordinator.

4.4.4.5.2 Use Case #2: LEED Neighborhood Development Rating (Pilot) of Proposed Scenarios

This scenario demonstrates the utility of spatially referenced space information about the physical configuration of buildings and their usage patterns in a greater urban context for the purposes of geospatial analysis. The specifics of the Use Case come from the LEED Neighborhood Development Rating System.[6], though depending on participant and sponsor interests other analyses of urban impacts may be considered, including planning and mitigation of neighborhood disturbance during the construction process, or evaluation of emergency scenarios involving multiple buildings and intervening urban conditions.

<table>
<tr><td>Use Case Identifier: CGB #2</td><td colspan="2">Use Case Name: Analyses to support Facility Planning and the draft LEED for Neighborhood Developments Rating System</td></tr>
<tr><td colspan="2">Use Case Domain: OWS-5 CGB</td><td>Status: Under development. Draft 04/11/07</td></tr>
<tr><td colspan="3">Use Case Description: This use case describes the integration of information about geospatial context from semantically rich city models with building information models for evaluating the environmental impact of site planning scenarios.</td></tr>
<tr><td colspan="2">Actors (Initiators): Building Developers, City or Campus Planners</td><td>Actors (Receivers) Same as initiators</td></tr>
<tr><td colspan="2">Pre-Conditions:
- As-Built information is available for buildings in a neighborhood
- A CityGML citymodel exists delineating neighborhood infrastructure and amenities
- These resources are available through OGC Web Services</td><td>Post-Conditions:
- Site planning and design are facilitated.
- The impact of various design scenarios are evaluated</td></tr>
<tr><td colspan="3">System Components
- WFS for BIM
- WFS serving CityGML
- BIM Authoring Tools for Site Planning
- BIM Authoring Tools for Space Planning
- GIS Tools for integrating CityModels and BIM information</td></tr>
<tr><td colspan="3">Basic Course of Action:
1. Phase 1: Information Infrastructure Development
2. A Base Commander, Campus Facilities Planner or City Planner calls for proposals for a new facility
3. Designers and developers develop a site plans for new buildings, integrating them within the context of a CityGML city model.
4. The building information is passed to the planner according to the specified Information Delivery Manuals.</td></tr>
</table>

[6] United States Green Building Council; Pilot Version LEED Neighborhood Rating System, 2007. http://www.usgbc.org/leed/nd

5. Planner evaluates impact of the new building in terms of runoff and visual quality and other aspects of the draft LEED Rating for Neighborhood Development.

4.4.5 CGB 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-5. This discussion will consider these according to the application areas discussed in the Enterprise Viewpoint.

4.4.5.1 Building Information Models Exchanged as IFC

The National BIM Standard relies on Industry Foundation Classes (IFC) as the model for structuring and encoding building information models for exchange between applications. IFC is a specification of the International Alliance for Interoperability.[7] IFC is an object model defined in the EXPRESS modeling language (ISO 10303-11) IFC are encoded and exchanged as STEP Physical Files (SPF) STEP is the **St**andard for the **E**xchange of **P**roduct Model Data (ISO 10303). IAI also has an XML schema for IFC that is less widely implemented.

4.4.5.2 Information Delivery Manuals and Model View Definitions

IFC is a generic container for structuring and exchanging building information specific applications are expected to use subsets of the IFC schema defined in Information Delivery Manuals (IDMs.) Information Delivery Manuals are human readable specifications of information needs. These are instantiated in a particular version of IFC as Model View Definitions (MVD.) Specific information for describing and encoding MVDs and IDMs is provided in Heitanen, 2006.[8]

The specific information content for the IDMs and MVDs that may be developed for OWS-5 is to be determined by the participants.

4.4.5.3 City Models Encoded and Exchanged as CityGML

CityGML is an information model for the representation of 3D urban objects. It defines the classes and relations for the most relevant topographic objects in cities and regional models with respect to their geometrical, topological, semantic and measured appearance properties. Included are generalization hierarchies between thematic classes, aggregations, relations between objects, and spatial properties. This thematic information goes beyond graphic exchange formats and allows users to employ virtual 3D city models for sophisticated analysis tasks in different application domains such as simulations, urban data mining, facility management, and thematic inquiries.

CityGML is realized as an open data model and XML-based format for the storage and exchange of virtual 3D city models. It is implemented as an application schema for the Geography Markup Language 3 (GML3), the extensible international standard for spatial data exchange issued by the Open Geospatial Consortium (OGC) and the ISO TC211. CityGML is intended to become an open standard and therefore

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[7] http://www.iai-international.org/Model/IFC(ifcXML)Specs.html

[8] Model View Definition Format; Jiri Heitanen, International Alliance for Interoperability, http://www.iai-international.org/software/mvd.shtml

can be used free of charge. The CityGML specification document is currently an OGC Discussion Paper. (http://www.citygml.org/)

CityGML is extensible through the use of external codelists and dictionaries. These will be useful for the rendition of specific MVDs from the IFC world in CityGML. For example it is likely that an external codelist will be developed for GSA Space Assessment Attributes, and for some subset of OmniClass feature types.

Figure 18: Visualization of a CityGML document

4.4.5.4 Mapping of IFC to CityGML

A key piece of the OGC architecture for bridging the AEC+FM workflows with Geospatial Information Infrastructure involves conversion of selected IFC objects to CityGML. In OWS-5 the specific information content and procedures for this conversion should be formalized as IDMs and MVDs, but also with procedures and software modules for converting these to CityGML Objects with appropriate property sets. A discussion of the issues and opportunities of converting IFC to CityGML can be found in Liebich 2004[9] and Benner and Leinemann 2005.[10]

4.4.5.5 Identifiers for IFC and CityGML Feature Collections

A critical benefit of integrating BIM with CityModels using the OGC Web Services Architecture is the ability to register models with catalog services so that these resources may be discovered and accessed though they may be served from distributed sites around the Internet. The OGC Catalogue Service Specification[11] is the source of the information requirements for registering feature collections. OWS-5 will provide an opportunity for participants to develop the specific information content that will be useful

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[9] IFG Project Phase 1: Comparison of GML3 and IFC2x2. Thomas Liebich AEC3 Ltd, Munich; http://www.iai.no/ifg/Content/Comparison%20between%20gml%20and%20IFC%20geometry.pdf

[10] Flexible Generation of Semantic Building Models; Benner and Leinemann, in Proceedings of the First International Conference on Next-Generation CityModels, Groeger and Kolbe Editors. EuroSDR Publication #49. http://www.eurosdr.net/km_pub/no49/workshops_docs/Citymodels_June_05%5Cpaper03_Benner.pdf

[11] Niebert and Whiteside, OGC Catalogue Service Specification Version 2.0, 2004

for discovering BIM information in CityModels and for developing the specific schemas for extracting these identifiers from IFC and encoding them in CityGML.

4.4.5.6 Identifiers for IFC and CityGML Feature Types

The NBIM Standard specifies that external standard taxonomies will be used to define specific feature types to be described in IFC. Discovery across many different models of particular types of features, for example, a specific type of space or a particular type of door, will be facilitated by an agreement to identify these features in a consistent way by all model developers. The fact that a particular type of feature exists within a specific feature collection is published by a Web Feature Service through its DescribeFeatureType interface. The standard taxonomy specified by NBIMS is Omniclass.[12] OWS-5 participants may develop IDMs and MVDs that specify Omniclass properties for features such as spaces. In order for these to be discoverable appropriately in catalogs, these will have to be translated to XML Schemas so that they can be published through the WFS DescribeFeatureType response.[13]

4.4.5.7 Coordinate Referencing Systems in IFC

The specification for IFC that is supported in most software applications today is IFC2x3. Geometric objects in a BIM formatted in IFC2x3 may have their vertices or other geometric parameters described in any regular cartesian coordinate system. Coordinates may be relative to other features and ultimately, through inheritance, to the coordinate origin for the IFC Site. A draft specification, IFC2x3g includes a Resource for geographic coordinate referencing systems that will permit the precise location of the site origin with a geodetically defined location. OWS-5 components may test of the CRS implementation for IFC2x3g. OWS-5 will not require client developers to implement IFC2x3g CRS resource completely; rather, all of the OWS-5 IDMs will include a property set that provides all of the information that is specified in IFC2x3g.

4.4.6 CGB Computational Viewpoint

The computational Viewpoint of the OGC Reference Model reflects the Components, Interfaces, Interactions and Constraints of the Service Architecture. A basic OGC architecture for CAD GIS and BIM was put together in OWS-4.[14] This section will discuss the new component capabilities that may be developed in OWS-5 along with any distinct interactions that these may engage. Following this, will be a discussion of interactions that will involve interoperability among new clients.

[12] Omniclass Construction Classification System, www.omniclass.ca

[13] Web Feature Services Specification

[14] OGC Architecture for CAD GIS and BIM, Paul Cote, 2007. OpenGIS Consortium Discussion Paper.

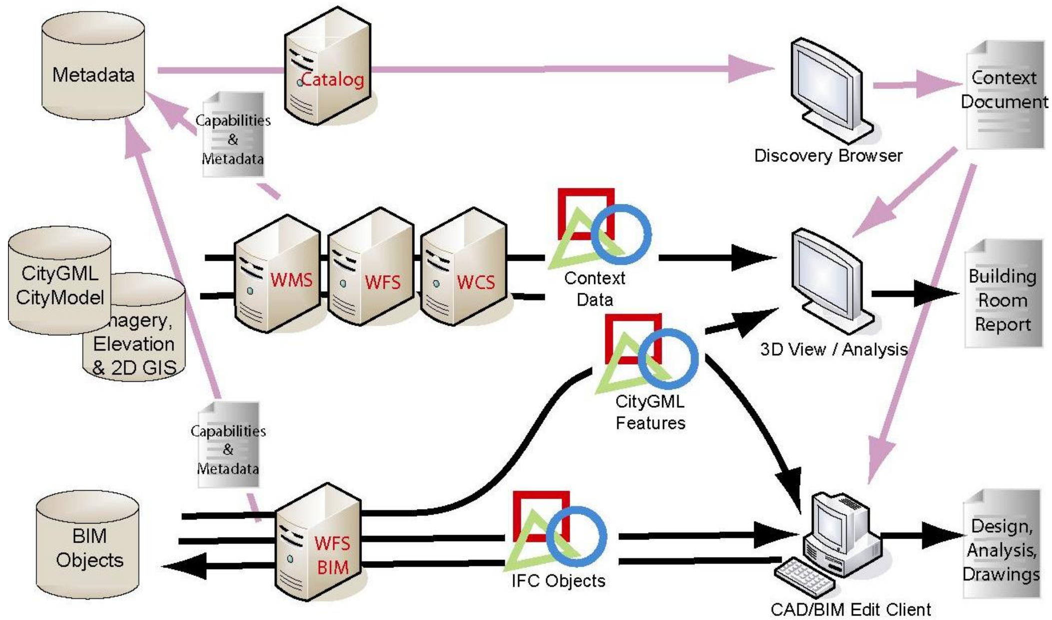

Figure 19: OWS-4 Architecture Overview

4.4.6.1 Web Feature Service for BIM

The heart of the architecture is the Web Feature Service for BIM, which adds the basic interfaces of WFS to a BIM server so that a predefined subset of BIM features can be requested either in IFC or GML format. The OWS-4 implementation used a feature-store based on the U.S. General Services Administration Space Assessment schema. The metadata published to the catalog service included the basic server capabilities and the names of the feature collections. OWS-5 may extend the vocabulary of exposed BIM features to handle a few more feature types defined in our OWS-5 IDMs. We will further exercise the metadata publishing for capabilities and specific feature types; filter encoding for retrieving features based on 3D'within' and 'Contains' queries, and retrieval of BIM data based on Xlinks embedded in CityGML objects are all possibilities for consideration in OWS-5.

4.4.6.2 Viewer Clients for CityGML

CityGML provides access to BIM features within a broader geospatial context. In OWS-4, the LandXplorer client was extended to provide real-time viewing and query capabilities of CityGML models from various servers. OWS-5 will provide opportunities to develop this capability in other clients, as well as new interactions, such as querying WFS for BIM features by following Xlinks, or retrieving information about specific feature-types that are nearby, or contain a clicked point. These functions will enable the Location-Based Services described Below.

4.4.6.3 Client for Indoor Location Based Services

The U.S. National Institute of Standards and Technology (NIST) report, Indoor Navigation for First Responders, suggests a simple architecture for indoor location-based services to aid emergency preparedness and response. This system makes use of a system for indoor location referencing (e.g. room numbers) or functional locations within the building (e.g. Atrium or Ventilation Shaft) These indoor location references will be defined in the BIM, and may be identified in the real world with RFID tags, which are also recorded in the BIM. A client developed especially to test this functionality would be able to hold a persistent BIM model in cityGML, and would be able to detect the signatures of nearby RFID tags. This would permit the client to "Know where it is" within the building, and to retrieve or query BIM features based on this information, or by following Xlinks from clicked objects.

There are many other architectures for indoor location-based services, including many using WiFi and other active radio transceivers and sensors. Any of these sorts of clients might be demonstrated in terms of its ability to encode queries to a WFS-for BIM to exchange local indoor location information into information about features near-by or explicit geospatial coordinates.

4.4.6.4 Analytical Clients for CityGML and other OGC Delivered assets

An advantage of providing access to BIM features over a broad area is the ability to do analysis based on this information. OWS-5 will provide opportunities to develop clients that will use features from the target IDM/MVDs , delivered from the WFS for BIM server, along with other cityGML information to create new information about combinations of geospatial features. Analyses to be carried out would be a subset of the LEED Rating System for Neighborhood Development. Possible other analysis may include shadow studies, view corridor analysis, watershed impact analysis, etc.

4.4.6.5 New Capabilities in BIM Authoring Tools

OWS-4 provided an opportunity for BIM editing clients to interoperate with various OGC services including the WFS for BIM. This activity will be continued in OWS-5. Beyond this, we may implement BIM authoring procedures geared toward facilitating and checking of specific Information Delivery Manuals and Model Definition Views. This will be an important step toward NBIMS implementation and also an important step toward developing tools for facility management via BIM and authoring CityGML via the CityGML MVDs.

4.4.6.6 CityGML Integration in GIS

OWS-4 provided an opportunity to develop capabilities for creating CityGML terrain from data in a geographic information system. This activity should be continued, both in the areas of terrain modeling and the development of other aspects of the CityGML application schema within a GIS environment. Of course, the ability to import and export CityGML will be encouraged.

4.4.6.7 Code Modules for Transforming Limited IFC Features to CityGML

The IFC Model View Definitions (MVD) for CityGML Levels of Detail (LOD) will be an important activity of OWS-5. These MVDs will greatly facilitate the process of creating CityGML from IFC. This conversion process will happen both on Servers and on authoring tools. The development of code modules (preferably open source) for converting specific BIM features, defined in a MVD, to CityGML will be a priority in OWS-5.

4.4.6.8 Resource Discovery on Clients

Software Client developers are encouraged to develop discovery interfaces related to BIM specific features or feature collections. Development and exploitation of OGC Context Documents is also encouraged.

4.4.6.9 Digital Rights Management Gateway Integration

WFS for BIM and Catalog Services for the Web should be able to provide or restrict access to specific information based on the privileges of the requestor and the security attributes of the features or metadata requested. GeoDRM gateway technology was developed in OWS-4. Participants in OWS-5 may explore the application of this technology in the context of BIM.

4.4.6.10 Transactions on BIM Attributes

Many transactions that may be made on BIMs in the course of facilities management may involve the simple manipulation of attributes. OWS-5 will provide a setting for the development of such interactions between BIM Authoring or BIM Viewer clients with the WFS-T for BIM.

4.4.7 CGB Engineering Viewpoint

Owing to the accommodation of cascading relative coordinate referencing systems in IFC BIM exchanges, and the constraint that all of the coordinate references for CityGML features are absolute, the WFS for BIM will need to be able to transform coordinate references while it is transforming features from IFC to CityGML. Furthermore, coordinate references in incoming filter queries may also need to be transformed from geospatial to local coordinates in order to find specific BIM features queried with reference to relative position to other building features or to out-door coordinates.

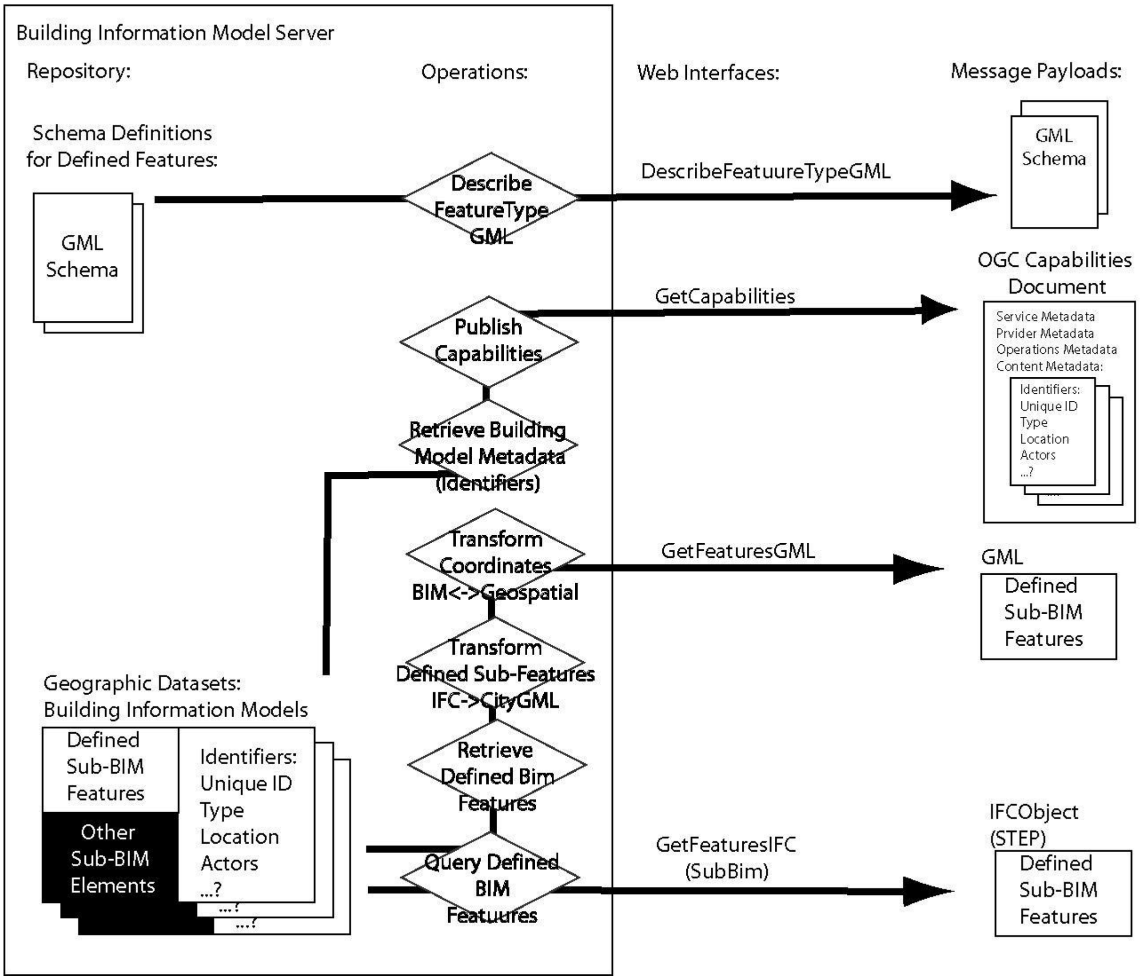

Figure 20: Web Feature Service for BIM

4.5 Agile Geography

The Agile Geography thread grows out of OGC initiatives to extend the Open Web Services architecture to the corporate and consumer mass markets. This work includes the development of lightweight profiles of existing OGC interface and encoding specifications, as well as the creation of new architectures when the traditional ones do not apply. Recent exemplars of Agile Geography include the:

- GeoRSS GML profile <http://www.georss.org/gml.html>,
- KML <http://portal.opengeospatial.org/files/?artifact_id=20598&version=1>,
- and the WFS Simple “semi-spatial” data retrieval interface <http://www.ogcnetwork.net/wfssimple>.

4.5.1 Agile Geography Scope

This testbed focuses on process integration and 'right-sizing' of services to demonstrate the power of interoperability and service-oriented architectures using OGC Web Services. The Agile Geography thread explores this goal through two distinct activities.

The first—GeoSynchronization and Sharing—extends the WFS Transactional architecture to target a federated environment comprised of loosely affiliated parties who desire to collaborate, in full or in part, on the maintenance of a shared geospatial data set.

The second activity explores the future of lightweight payloads of geospatial information on the Web, applying the concepts of links, bookmarks and Web pages to digital cartography and geospatial information management. Participants will explore the harmonization of KML and OWS Context document encodings and prototype client and server software that exploits these documents.

4.5.2 Planned Activities

4.5.2.1 Federated Geo-synchronization Services

A significant aspect of geospatial information management is the administration of database changes. As spatial databases become more distributed and collaboratively maintained, traditional database transaction models are not sufficient to handle modern scenarios. Important updates may come in from remote field workers, external (but trusted) organizations, or even anonymous Internet users. Identities must be confirmed, and updates must be validated, applied, and potentially disseminated to remote copies with the possibility for versioning and rollback.

It is expected that realization of this technology will leverage concepts from a variety of fields, within as well as external to the geospatial industry. For security and identity, GeoDRM work will have a central role. For transactions on a spatial database, the WFS-Transactional service is of interest. In architecting the concepts and methods of synchronization, change dissemination, and rollback we expect to employ lessons learned from document versioning, peer-to-peer networking, and collaborative editing systems.

This work area investigates architectures and prototypes software components for enabling what we are calling Federated Geo-synchronization Services. In OWS-5 we will look at a scenario involving the management of a forestry database by a mix of user types—employees working in the field and less-trusted anonymous users, and two client environments—graphical PDA-based clients and automatically parsed GPS logs.

4.5.2.2 KML & Context Investigations

KML is perhaps the most widely deployed geospatial information format on the Web today. Google, Inc. has recently submitted KML for international standardization through the OGC as a means to manage the evolution of KML to keep pace with user requirements, and accelerate the use of geospatial information throughout society.

The first result of this process is the *KML Reference Document* <http://portal.opengeospatial.org/files/?artifact_id=20598&version=1>. This document restates the content of Google's KML version 2.1 XML encoding. The work items in OWS-5 are OGC's initial efforts to better align KML with existing OGC specifications—particularly the Open Web Services stack.

KML and the existing OGC OWS Context document encoding specification have a lot in common. Both encodings support the specification of a location on Earth, dynamic access to certain geospatial Web resources and services, and inline inclusion of geospatial data along with simple styling. Therefore, it is expected that KML and Context will to some extent converge. This is why this work item is called KML & Context Investigations, although much of the work will explicitly focus on the KML format.

We hope to achieve two primary goals in this work item—expand the universe of clients and services that can use the KML format, and increase the expressiveness of KML to support more OGC service types. In this testbed a range of clients and services will be developed to support KML with the inclusion of basic Web Feature Services, and an additional emphasis on exploring the existing KML support for imagery annotation.

4.5.3 Agile Geography Requirements

Federated Geo-synchronization Services
1) Geo-synchronization server
a) Ingest GML Simple Features Level 0 and GeoRSS GML feature data from two or more Geo-synchronization clients (which are also potentially WFS-T clients)
b) Provide change reports showing feature differences between one time and another for any subset of the database as specified by a Filter encoding
c) Support rollback of the database to any arbitrary point in time
2) Geo-synchronization client
a) PDA client
i) Make a WFS request to a server for features
ii) Graphically edit spatial features
iii) Authenticate and transact features back into federated database
b) GPS log (GPX) translation client
i) Authenticate and transact features back into federated database
3) GeoDRM license broker
KML & Context Investigations
1) Develop an Component WMS (also known as Feature Portrayal Service) that outputs KML
2) Add WFS Basic (and/or WFS Simple) support to KML using Context as an exemplar
3) Ingest KML and Context documents (service) and make WMS and WFS requests (client)
4) Define a methodology for including GML 3 content in KML/Context
a) GeoRSS GML
b) GML Simple Features Level 0
c) CityGML
5) Develop a client that supports imagery annotation and can express this activity in a KML file with Overlay elements

4.5.4 Agile Geography Deliverables

The following Interoperability Program Reports (IPRs) will be developed in OWS5-Agile Geography and submitted to the OGC Specification Program at the completion of the OWS-5:

1)	Federated Geo-synchronization Services IPR
2)	KML/OWS Study IPR

Implementations of the following services and tools and data instances will be developed in OWS5-Agile Geography, tested in Technology Integration Events (TIEs) and invoked for cross-thread scenarios for OWS-5 demonstration events:

1)	Federated Geo-synchronization Service
2)	Federated Geo-synchronization Client
3)	GeoDRM Broker Service
4)	GeoDRM Encoding for Federated Geo-synchronization
5)	KML WFS Client
6)	KML GML Client
7)	Component WMS (FPS) with KML output
8)	KML Imagery Annotation Client

4.5.5 Agile Geography Enterprise Viewpoint

The Agile Geography vision relies heavily on the emerging concepts and patterns generally referred to as "Web 2.0". These systems have been successful in using simple technologies to harness the collective intelligence of users to create systems that:

- Leverage foundational, standards-based Web technologies
- Scale exponentially in value while scaling linearly in resource utilization
- Support diverse system architectures
- Are easy to adopt in a range of enterprise and consumer environments
- Are highly resilient to systems failures and intentional attacks

In contrast to existing OGC Web services, which often emphasize sophisticated functionality over ease of implementation, the Agile Geography architecture views universal participation as the most important design goal. Software features—even simple ones—inherently increase implementation costs, and therefore exclude some users. Since the key to the success of Web 2.0 architectures is the network effects created by immense user bases, interface simplicity must be maintained at the cost of elegance and sophistication.

As part of OGC's mission to make geographic content and services ubiquitous, we envision a layer of the OGC services stack that aligns with those architectures currently characterized as Web 2.0. Technologies developed in the Agile Geography thread should seek to emulate these attributes while retaining alignment with the traditional OGC Web services designed for geospatial professionals.

The Agile Geography Enterprise Viewpoint captures the capabilities that must be present in support of geospatially enabled mass market activities and operations. The capabilities identified here describe the requirements to be met by the OWS computation and information models. The Enterprise Viewpoint is defined by a high-level system concept and use-cases. The system concept illustrates the operational setting, major system components and key interfaces. The use cases provide descriptions of the behavior of the system from the point of view of enterprise users.

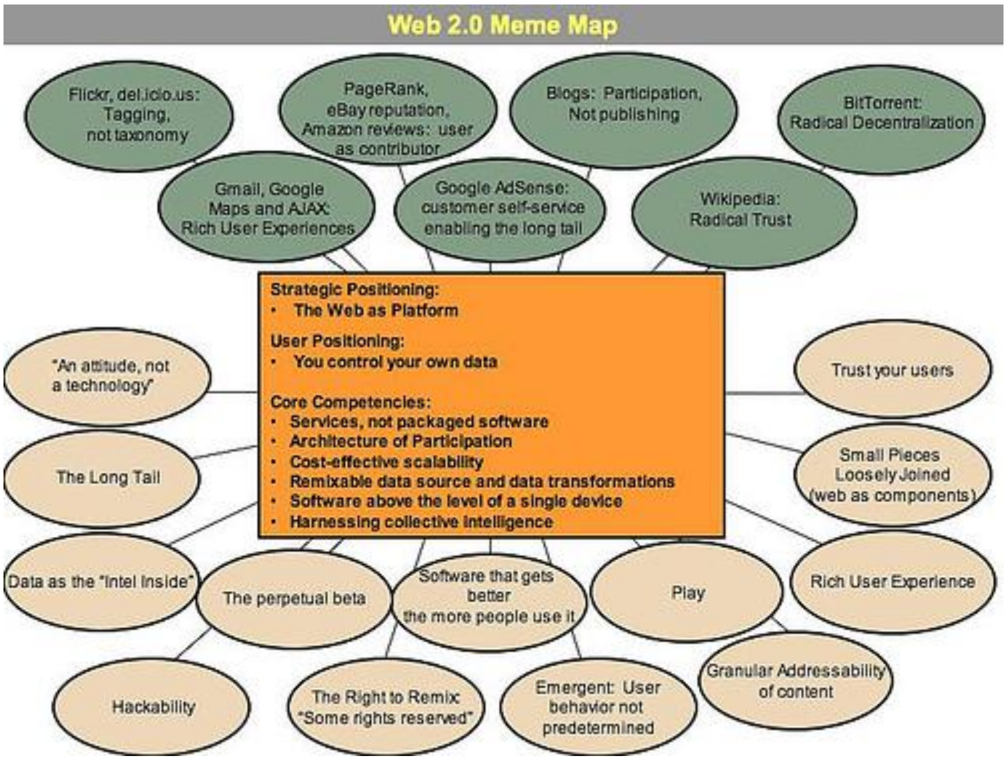

Figure 21: Web 2.0 Meme Map from "What Is Web 2.0" by Tim O'Reilly (http://www.oreillynet.com/pub/a/oreilly/tim/news/2005/09/30/what-is-web-20.html)

4.5.5.1 Use Cases

4.5.5.1.1 Use Case #1: Forestry Geo-synchronization

Use Case Identifier: OWS5 AgileGeo #1	Use Case Name: Forestry Geo-synchronization
Use Case Domain: OWS-5 Agile Geography	Status: Draft 04/02/07
Use Case Description: Field offices are extending geographic data sets on a PDA while disconnected and away from the office. The data needs to be loaded back into the master database when the user returns to the office. Ideally, version information should be stored, access rights managed etc.	
Actors (Initiators): Forester (A)	Actors (Receivers): Forester, Forestry database (DB)
Pre-Conditions: - Forestry database available - The available information resources have been cataloged, and pertinent catalogs are known - Forester has access credentials	Post-Conditions: Feature updates made in field have been synchronized with database.

System Components - See section 4.5.2.1— Federated Geo-synchronization Services
Course of Action: 1. A accesses DB using sync client via Geo-synchronization Service 2. A selects a subset of DB content for use 3. A modifies content using editing client 4. DB validates access privileges of A 5. Repeat Action #1 6. A uses Sync client to update DB via Geo-synchronization Service

4.5.5.1.2 Use Case #2: Web/GPS Geo-synchronization

Use Case Identifier: OWS5 AgileGeo #2	Use Case Name: Web/GPS Geo-synchronization
Use Case Domain: OWS-5 Agile Geography	Status: Draft 04/02/07
Use Case Description: Local experts contribute to a shared geographic data resource.	
Actors (Initiators): Local expert (A)	Actors (Receivers): Shared Web database (DB)
Pre-Conditions: - The available information resources have been stored	Post-Conditions: Features have been synchronized with database.
System Components - see section 4.5.2.1— Federated Geo-synchronization Services	
Course of Action: 1. A accesses a Web site providing access to DB 2. A uploads a GPS log in GPX format to be included in DB 3. DB validates access privileges of A 4. DB walks A through reconciling GPS content with pre-existing features and properties 5. DB saves new content	

4.5.5.1.3 Use Case #3: Geo-synchronization History

Use Case Identifier: OWS5 AgileGeo #3	Use Case Name: Geo-synchronization History
Use Case Domain: OWS-5 Agile Geography	Status: Draft 04/02/06
Use Case Description: The history of changes to a geographic database are viewed, accepted, and removed.	
Actors (Initiators): System moderator (A)	Actors (Receivers): Shared Web database (DB)
Pre-Conditions: - The available information resources have been stored	Post-Conditions: DB is viewed and modified.

System Components - see section 4.5.2.1 — Federated Geo-synchronization Services
Course of Action: 1. A queries DB for a certain set of changes (e.g. by user, by date, or by area) 2. DB validates viewing privileges of A 3. A views the effect of the changes in a mapping client 4. A selects changes to be edited in a “change editing client” 5. A “rolls back” a subset of changes 6. DB validates editing privileges of A 7. A submits “rollbacks” to DB

4.5.6 Agile Geography Information Viewpoint

4.5.6.1 KML

Relevant specifications:

- KML Reference Document (OGC 07-039)

KML is a file format used to display geographic data in an Earth browser, such as Google Earth, Google Maps, and Google Maps for mobile. KML uses a tag-based structure with nested elements and attributes and is based on the XML standard.

You can create KML files with the Google Earth user interface, or you can use an XML or simple text editor to enter "raw" KML from scratch. KML files and their related images (if any) can be compressed using the ZIP format into KMZ archives. To share your KML and KMZ files, you can e-mail them, host them locally for sharing within a private internet, or host them publicly on a web server. Just as web browsers display HTML files, Earth browsers such as Google Earth display KML files. Once you've properly configured your server and shared the URL (address) of your KML files, anyone who's installed Google Earth can view the KML files hosted on your public web server.

4.5.6.2 OWS Context

Relevant specifications:

- OWS Context IE Final Report (OGC 05-062)
- Context XML Schema documents (http://schemas.opengis.net/context/)

An OWS Context document is an XML encoding referencing remote and/or local OGC Web Services and static content. OWS Context documents are related to, but more powerful than, Web Map Context Documents (03-036r2). The latter are limited to referencing OGC Web Map Services (WMS), whereas the former can reference other OGC Web Services, e.g. Web Feature Services (WFS), Web Coverage Services (WCS), etc.

4.5.6.3 GML

Relevant specifications:

- OpenGIS® GeoRSS – Draft White Paper (OGC 06-050r1)
- GeoRSS GML web site (http://georss.org/gml/)
- Geography Markup Language (GML) Simple Features Profile (OGC 06-049)
- City Geography Markup Language (OGC 06-057r1)
- CityGML web site (http://citygml.org)
- OpenGIS® Geography Markup Language (GML) Encoding Specification 3.2 (OGC 05-108r1)

The default feature encoding format for OWS-5 is GML 3.2. A number of GML profiles may be supported in this thread, including but not limited to GML Simple Features Level 0, CityGML, GeoRSS GML, NSG feature catalog, and GML Point Profile.

4.5.6.4 Styles and Symbology

Relevant Specifications

- OWS-4 Feature Styling IPR (06-140)
- SLD profile of WMS (05-078r3)
- Symbology Encoding Implementation Specification (OGC 05-077r3)
- Symbology Management (OGC 05-112r1)

Under OWS-5, participants will seek to harmonize styling in KML and Context. Styles are the application of symbols to geographic information, to create a cartographic product. Symbols are pieces of graphics used by Portrayal Services to represent geographic features on a map. Symbols are the instructions for how vector and raster graphics are to be portrayed. Vector graphic symbols may have properties such as geometry, graphic, fill, color, stroke, font, orientation, size, opacity etc. Raster graphic symbols may have properties such as opacity, RGB channel selection, color map, shaded relief, contrast enhancements, etc.

Symbols may be represented as a set of graphical instructions using encoding languages such as SLD, SVG or CGM or as a raster graphic (image file) encoded in one of a set of standard formats (e.g., JPG, PNG, GIF, CGM). In principle, any number of Symbol representations may be used with a styling architecture.

4.5.6.5 Web Naming and Addressing

Relevant Specifications

- Those found at http://www.w3.org/Addressing/

Uniform Resource Identifiers (URIs, aka URLs) are short strings that identify resources in the web: documents, images, downloadable files, services, electronic mailboxes, and other resources. They make resources available under a variety of naming schemes and access methods such as HTTP, FTP, and Internet mail addressable in the same simple way.

4.5.6.6 JSON and GeoJSON

Relevant Specifications

- http://www.json.org
- http://wiki.geojson.org and http://icon.stoa.org/trac/pleiades/wiki/GeoJSON

From http://www.json.org: JSON (JavaScript Object Notation) is a lightweight data-interchange format. It is easy for humans to read and write. It is easy for machines to parse and generate. It is based on a subset of the JavaScript Programming Language, Standard ECMA-262 3rd Edition - December 1999. JSON is a text format that is completely language independent but uses conventions that are familiar to programmers of the C-family of languages, including C, C++, C#, Java, JavaScript, Perl, Python, and many others. These properties make JSON an ideal data-interchange language.

GeoJSON is a nascent initiative to develop geographic JSON encodings.

4.5.7 Agile Geography Computational Viewpoint

4.5.7.1 Web Mapping Service

Relevant Specifications: *OpenGIS® Web Map Server Implementation Specification version 1.3 (06-042)*
Styled Layer Descriptor profile of the Web Map Service Implementation Specification (05-078r3)

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. In ICS the WFS will provide feature access to Local MSD data.

4.5.7.2 Web Feature Service

Relevant Specifications: *OpenGIS® Web Feature Service version 1.1*

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.

4.5.7.3 Web Feature Service — Simple

Relevant Specifications: *http://www.ogcnetwork.net/wfssimple*

WFS Simple specifies a common, minimal feature set for geospatial-temporal data queries on the Web. Its' primary goal is to encourage databases with basic location information (like lat/long coordinates), to support location-aware queries. Most mainstream Web systems, like blogging engines and standard PHP/MySQL setups, should be able to easily add WFS Simple functionality by supporting two standardized parameters, BBOX and TIME, in queries.

The primary differences between the OpenGIS Web Feature Service Specification© and WFS Simple are:

1. GML is not a required output format
2. There is no HTTP POST encoding of a WFS Simple request

3. Only one Feature Type is allowed per service instance (therefore the TypeName parameter goes away)

Query support is optional (this applies to WFS also, but it is important to emphasize)

4.6 Compliance and Interoperability Test and Evaluation (CITE)

4.6.1 Scope

Validating compliance with an OGC specification means verifying that a software product has implemented the specification correctly by testing the software interface for response and behavior that is outlined in the specification. Verifying compliance to the standard is necessary in order to achieve interoperability. As a result, geospatial application vendors desire to provide their potential costumers a means to verify adherence to OGC standards as a measurable discriminator for the interoperability of software products. Similarly, users desire assurance that acquired software components will interoperate with their existing investments in OGC-compliant technology. The Conformance and Interoperability Test and Evaluation (CITE) thread is intended to provide the geospatial industry (consumers and vendors) a methodology and tools that will test compliance with OGC web services.

The OGC Interoperability Program and the OGC Specification Program have achieved a great deal of momentum as a result of the multiple OGC web service specifications that have recently been published. Key consumers in the geospatial industry are modernizing their enterprises based on the applicability and interoperability of OGC web services. The major geospatial industry consumers require verifiable proof of compliance with OGC specifications in order to reach the desirable outcome of interoperability. Furthermore, as the OGC technology stack has matured, a group of interfaces has emerged that represents a baseline of technology needed to implement a fully interoperable, end-to-end *spatial data infrastructure*. The OWS-4 CITE thread made significant progress towards having a complete suite of compliance tests for this baseline of interfaces. In OWS-5, transitioning the WCS 1.0 compliance tests to the new, open source TEAM Engine will complete this work.

A major focus of OWS-5 is enterprise workflow. To that end, the CITE thread will develop SOAP and WSDL compliance test suites and reference implementations for four specifications, WFS, WMS, WCS and CS/W. A reference implementation is an open source, fully functional implementation of a specification in reference to which other implementations can be evaluated. The OGC provides open source reference implementations to ensure maximum transparency of its specifications for both vendors and customers.

4.6.1.1 Problem and Objectives

The CITE thread will develop a suite of compliance test scripts for testing and validation of products with interfaces implementing the OpenGIS® specifications listed below. These scripts will be written for the new Testing, Evaluation, and Measurement (TEAM) engine. The participants in this thread will develop Interoperability Program Reports (IPRs) outlining the developed test guidelines and test scripts. These IPRs will be presented to the Technical Committee and Planning Committee for approval. All development activities within the CITE thread should result in products that are fully functional on a Linux platform on the OGC IT infrastructure, excluding reference implementations which may be served from a vendor's facility.

4.6.1.2 Planned Activities

In general, the planned activities for the CITE thread involve creating compliance test scripts for the required technologies. However, due to the fact that the TEAM engine is open source, if additional functionality is needed to complete the test requirements, it is expected that the participant will be able to make enhancements to the engine at the code level. In your proposal, please describe your ability and willingness to work with the technologies the TEAM engine is built upon—i.e. Java and the Saxon XSL interpreter.

4.6.2 CITE Deliverables

The following Interoperability Program Reports (IPRs) will be developed in OWS5-CITE and submitted to the OGC Specification Program at the completion of the testbed. All IPRs will include the code for the completed compliance test script suites.

1) CITE IPR

Implementations of the following services, tools and data instances will be developed in this OWS-5 thread, tested in Technology Integration Experiments (TIEs) and invoked for cross-thread scenarios for OWS-5 demonstration events:

WCS – Web Coverage Service
1) Port WCS 1.0 compliance test script suites from the OpenGroup engine to TEAM engine
2) Develop compliance test script suites for WCS 1.1
3) WCS 1.1 Reference Implementation
WFS 1.1 – Xlink
1) Extend compliance test script suites for WFS 1.1 for XLink
2) Extend WFS 1.1 Reference Implementation for XLink
CSW – Catalog Services for the Web
1) Develop compliance test script suites for CSW 2.0.2 ebRIM/ISO 19115 profile
2) CSW 2.0.2 ebRIM/ISO 19115 Reference Implementation
SOS – Sensor Observation Service
1) Develop compliance test script suites for SOS with SensorML, TML, NITF, JPEG2000 encoding support
2) SOS Reference Implementation
SPS – Sensor Planning Service
1) Develop compliance test script suites for SPS

2) SPS Reference Implementation
TEAM Engine
1) Maintenance

4.6.3 CITE Enterprise Viewpoint

The CITE thread provides a framework to test conformance of software components to OGC specifications. The foundation of this framework lies in the globally dispersed data exchange technologies provided by the Internet and World Wide Web. The Compliance Engine for an OGC specification accepts one or more Compliance Test Suites. These suites will be run against a candidate OGC-compliant software component. The results of the test will be codified in a Compliance Test Report, indicating success or failure and as much detail as possible regarding the reasons for such.

Passing the compliance tests means that a product should be interoperable with any other product that passes the same tests. In practice, compliance is not sufficient to guarantee interoperability, due to slight differences in implementations and imprecision in the original specification, combined with variances in performance that certain data sets may expose. This is why integration experiments and plugfests are key components of interoperability testing. However, compliance testing is a necessary, crucial step along this continuum.

4.6.4 CITE Information Viewpoint

The primary information concepts in CITE are the “test suite”, “test script”, a “test”, and an “assertion”. A test suite is a collection of test scripts that validate compliance with a named technology. The technology may be an OpenGIS® implementation specification, an encoding specification, or a profile or subset of either.

While a test script does not have a strict formal definition, the term is usually used to refer to a collection of tests that validate compliance with a particular Web service operation.

A test is an XML file covering one assertion, or statement of required behavior that is derived from a specification. Tests typically contain one or more requests that are sent to the service begin tested, and XPath expression(s) that are evaluated against the results to determine whether the test passed or failed.

The test files also contain textual information describing the assertion being tested and how the test is performed. The engine automatically assembles this information to generate an assertions document describing each test the test suite is capable of performing.

In addition to the tests, the engine can be configured to prompt the user for information in the form of "scopes" which determine which tests will be executed for the session, or "variables", which can be used in the tests themselves.

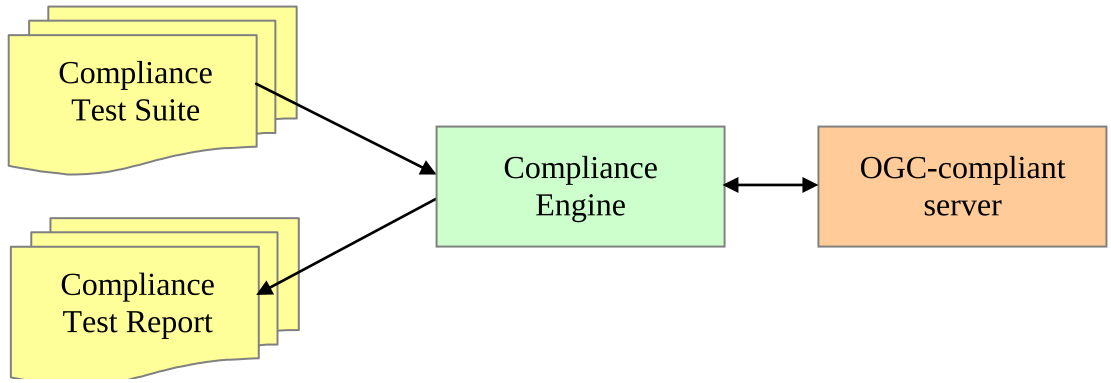

Figure 22: CITE

4.6.5 CITE Engineering Viewpoint

Figure 23 below depicts the architecture of the TEAM engine. In developing tests for the engine, participants have the option to extend the engine's functionality by writing custom functions and parsers. These may either be developed in XSL, or when needed, Java 1.4 with the Saxon XSL interpreter [http://saxon.sourceforge.net/].

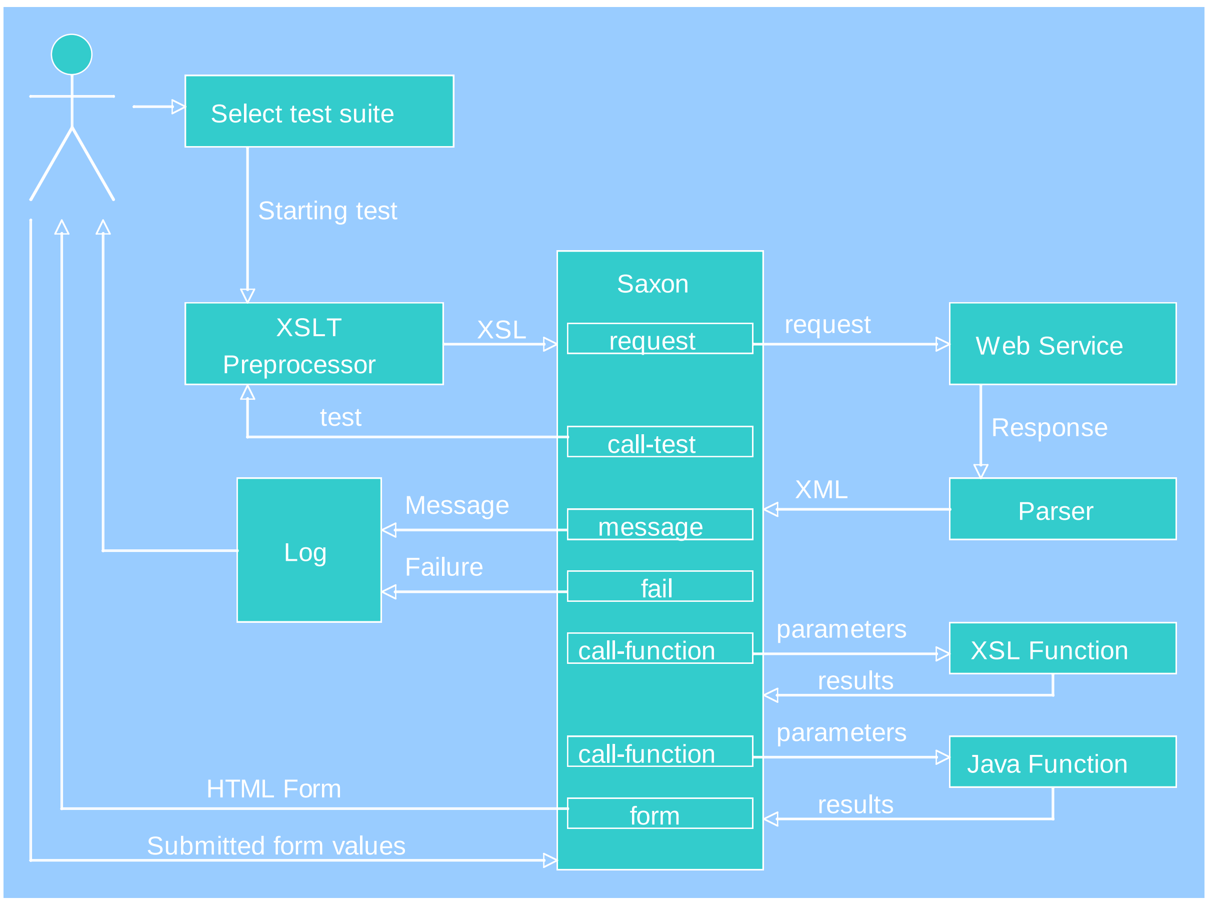

Figure 23: Architecture of the TEAM engine