Request for Information (RFI)
for
OGC Fusion Standards Study

RFI Issuance Date: 16 July 2009

Response Due Date: 12 August 2009

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ABSTRACT

The Open Geospatial Consortium (OGC®) issued this Request for Information (RFI) to solicit industry input into a Fusion Standards Study to be conducted in preparation for the planned OGC Web Services, Phase 7 (OWS-7) Testbed. OGC also seeks to establish alliances with other Standards Development Organizations (SDOs) having technology relevant to fusion.

In the context of this RFI, "Fusion is the act or process of combining two or more pieces of data or information regarding one or more entities in order to improve the capability for detection, identification, or characterization of that entity".

This RFI is based on requirements and contributions from several OGC Member organizations, including the National Geospatial-intelligence Agency (NGA), BAE Systems - C3I Systems, and Lockheed Martin.

The overall Fusion Standards Study will conduct a survey of standards and implementations that support geospatial fusion; will review existing standards regarding fusion; will recommend future standards or integration of other standards; and will plan for evaluating standards through OGC's OWS-7 testbed to be conducted later this year.

This RFI puts forth some challenging issues. Your responses to this RFI along with sponsor resources will determine the particular focus areas to be undertaken during the execution phase of future testbeds. We further hope that the responders will indicate their readiness to contribute to the realization of that environment.

Responses to the RFI should describe fusion processes that your organization sees as feasible in a distributed information environment.   The description of the fusion process can be accomplished by providing requirements and use cases as well as product descriptions and capabilities. Responses should include identification of relevant existing standards and where new standards might be needed.

Responses to the RFI are requested by August 12, 2009. This RFI includes instructions for how organizations can respond. Please contact George Percivall at gpercivall@opengeospatial.org with any questions.

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1   Introduction

1.1   RFI Purpose and Scope

This RFI is part of a survey to assess the current state of standards and implementations that support information fusion for many areas including intelligence, surveillance and reconnaissance. The RFI includes many functional areas with an emphasis on geospatial fusion. Information contained in RFI Responses will be used in the planning of future activities including the OWS-7 testbed.

The OGC Interoperability Program utilizes a multi-step methodology in defining an interoperability initiative. Part one of the methodology is to use an RFI to gain better understanding of the current state of a given technology thrust and discover stakeholder insights about the architecture(s) to be used in subsequent testbeds.

1.2   The Open Geospatial Consortium

The Open Geospatial Consortium (OGC) is an international not for profit voluntary industry consensus standards organization that provides a forum and proven processes for the collaborative development of free and publicly available interface specifications (open standards). These open standards enable easier access to and use of geospatial information and improved interoperability of geospatial technologies (across any device, platform, system, network or enterprise) to meet the needs of the global community. OGC open standards have been implemented broadly in the marketplace and are helping to foster distributed and component technology solutions that geo-enable web, wireless, and location based services as well as broader government and business IT enterprises worldwide.

To accomplish the mission of the Consortium, OGC conducts three programs:

- OGC's Specification Program facilitates formal consensus-based committees, working groups and special interest groups that establish a forum for OGC's industry, academic/research and user community members to collaboratively identify, prioritize and advance solutions to meet standards needs of the global community.

- OGC's Interoperability Program promotes rapid prototyping, testing and validation of emerging standards through fast paced testbeds, experiments, pilot initiatives and related feasibility studies.

- OGC's Outreach and Community Adoption Program conducts programs (training, articles in publications, workshops, conferences, etc) to promote awareness and implementation of OGC standards across the global community.

This RFI is issued by the OGC Interoperability Program based upon interest and contributions from several OGC Member organizations, including, the National Geospatial-intelligence Agency (NGA), BAE Systems - C3I Systems, and Lockheed Martin.

2   Fusion Standards Study Objectives

Fusion Standards Goal: The fusion standards study sponsors goal for defining and developing fusion standards is to give analysts an environment where they can use interoperable tools to analyze, process and exploit two or more different types of data or products from the same or multiple sensors and databases utilizing just one system.

Fusion Portfolio Objectives: Developing new or exploiting current capabilities for fusing information from multiple sensors, from multiple sources, and from multiple INTs in ways that dramatically improve the ability to detect, indentify, locate, and track objects. Research addresses fusing information from different sensors of the same modality, fusing information from IMINT sensors of different modalities (e.g. fusing LIDAR, hyperspectral, and OPIR), fusing information from different INTs (e.g. fusing IMINT and SIGINT), fusing disparate GEOINT data types, developing new ways to reason and make decisions from

fused information, and providing fusion-based solutions to hard problems in a net-centric environment. The research also addresses measurements and databases for fused and composite signatures of targets of interest, conflation of multi-sensor, multi-modality data, and development of automated fusion exploitation algorithms for hard problems.

This RFI is an element of a market survey of the current state of standards and implementations (commercial and open source) to determine the as-is level of support for standards based geospatial fusion with specific interest in fusion of multi-INT sources in a net-centric environment. This market survey shall identify the level of maturity of identified standards and implementations to include any previous testing of these standards and services which may have occurred as part of the OGC interoperability program such as testbeds, interoperability experiments, etc.

3   Fusion Technical Description

3.1   Definition of Fusion

The working definition used for this RFI is "Fusion is the act or process of combining two or more pieces of data or information regarding one or more entities in order to improve one's capability (or provide a new capability) for detection, identification, or characterization of that entity".

According to the Joint Directors of Laboratories (JDL), data fusion is "A process dealing with the association, correlation, and combination of data and information from single and multiple sources to achieve:

- Refined position and identify estimates, and
- Complete and timely assessments of situation and threats, and their significance"

The process is characterized by continuous refinements of its estimates and assessments, and by evaluation of the need for additional sources, or modification of the process itself, to achieve improved results.

Standards Based Fusion

Much of the fusion processes described in this RFI can be achieved in multiple closed architectures with existing single provider software and hardware solutions. Fusion is not a new topic.   The problem addressed by this RFI is to move those capabilities into an distributed architecture based upon open standards including standards for security, authorization, and rights management.

> State A (As-Is): Lack of identified and adopted standards results in multiple islands of data and stovepipe applications and services that are difficult to automate and scale for large data volumes and challenging analytical problems.

> State B (Target): Standards-based data, applications and services enable an automated and interoperable fusion environment supporting secure sharing of data and transparent reuse of pluggable services for handling large data volumes and unanticipated analytical challenges.

It is recognized that OGC standards, as well as other industry standards, can be employed to enable or enhance fusion. OGC and other standards are listed in the various sections below in brief with full citations in the Appendix. This RFI seeks information to help discern how these and other standards have been or might be applied to meet the demands for data fusion.

Fusion Categories

As indicated in the working definition of fusion listed above, fusion processes can apply to many types of entities. Categories of fusion depend on the processing stage or semantic level at which fusion takes place. Fusion processes are often categorized as shown in Figure 1. Sensor Fusion combines several sources of raw data to produce new raw data that is expected to be more informative and synthetic than the inputs. This kind of fusion requires a precise (pixel-level) registration of the available images. In intermediate category, Object or Feature Fusion, various features such as edges, corners, lines, texture parameters, etc are combined into a features and map that may then be used by further processes. Decision Fusion supports

near-real-time manipulation and sharing of massive amounts of increasingly complex information collected and fused from diverse data sources to support decision making.
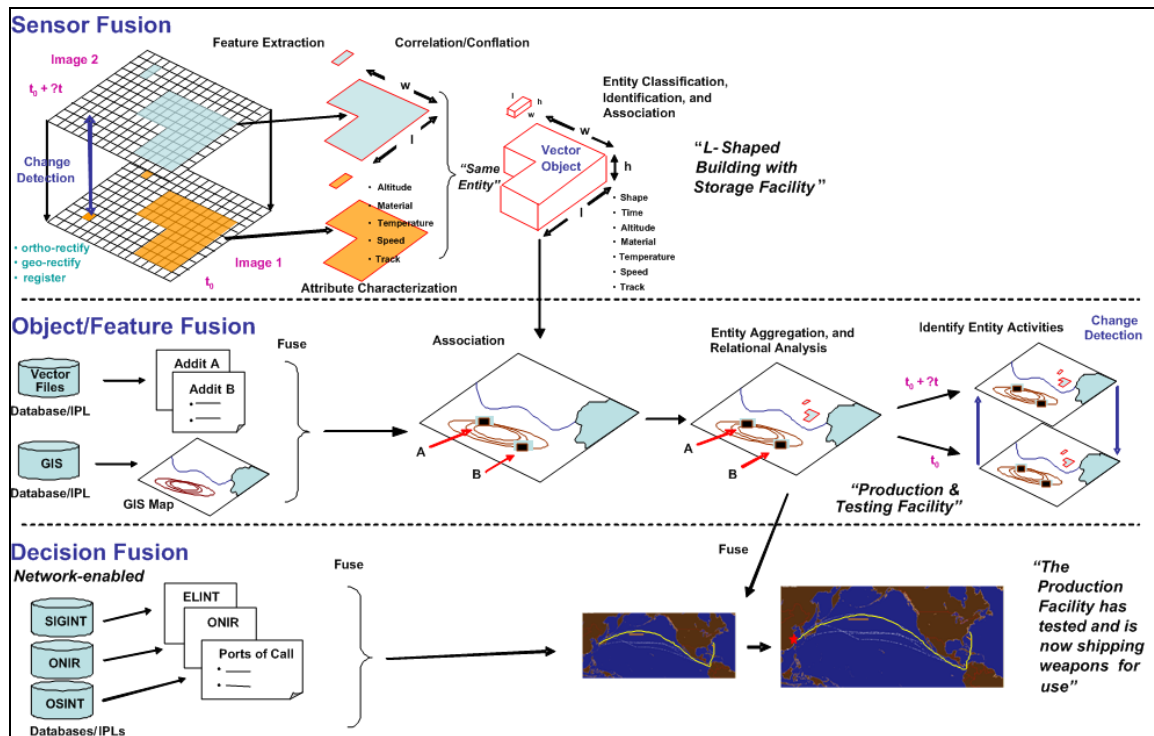

Figure 1 – Fusion Categories

This RFI is organized around three categories of fusion that build upon the categories displayed in Figure 1. The three categories are consistent with geographic information ranging from sensor measurements through feature operations to decision support. The three categories used in this RFI are:

- Sensor Fusion: ranging from sensor measurements of various phenomena to well characterized observations including uncertainties. Fusion processes involve merging of multiple sensor measurements of the same phenomena into a combined observation; and analysis of the measurement signature.

- Object/Feature Fusion: including the processing of observations into higher order semantic features and feature processing. Object/feature fusion improves understanding of the operational situation and assessment of potential threats and impacts by to identify, classify, associate and aggregate entities of interest. Object/feature fusion processes include generalization and conflation of features.

- Decision Fusion: focuses on client environments for analysts and decision makers to visualize, analyze, and edit data into fusion products for an understanding of a situation in context. Decision fusion includes the ability to fuse derived data and information with processes, policies, and constraints. Collaborate with other analysts is done using social networking services and collaboration tools that are location enabled.

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

Organization of Fusion Sections

The following sections present the three categories of fusion using a common outline (Table 1). This common outline is based upon the commonality of the fusion process across the three fusion categories. Each of the categories has a common approach as shown in Figure 2.

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Table 1 – Common Outline for Fusion Sections

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Fusion Objectives	The objectives associated with combining information from multiple sources or of different properties to gain better situation awareness
Enabling Capabilities	Those technical capabilities that will enable or enhance fusion capabilities. Description of fusion Processes.
Objects from Fusion Processes	Description of the information types that result from the fusion processes
Tools, Resources and Standards	Tools and Resources with relationship to existing standards that enable fusion are listed. Areas that could benefit from standards development are identified. Standards that appear in the RFI are listed in full in the Appendix.

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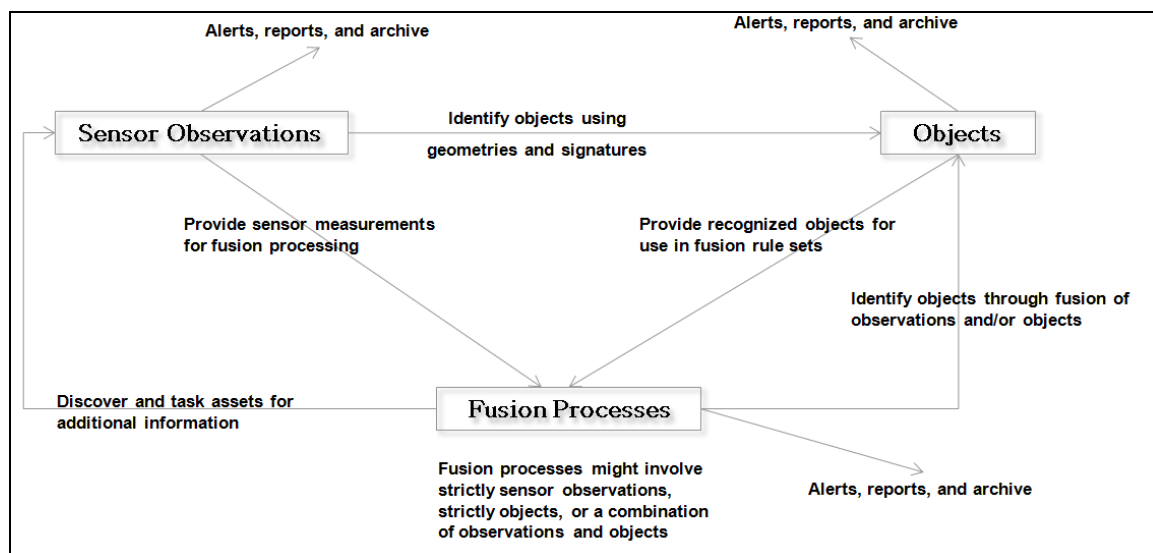
Figure 2 – Fusion processes

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Each of the elements of Figure 2 are described in the following:

Sensors Observations. Much information suitable for fusion begins with or is derived from observations by sensors or humans. This is particularly true for information that is highly dynamic in nature and of a timely nature. These observations, either raw or processed, can serve as input into fusion processes or they may be used to identify recognizable objects or features that are then treated as input into a fusion process, as illustrated in Figure 2. Identification of objects from sensor observations typically relies on comparison of these observations against known signatures for select objects or on the use of various classification algorithms. Signatures can be sensor or signal-dependent, and may be based on geometry, electromagnetic response, or on the combination of properties measured by multiple sensor types. The results of sensor observations or object recognition can be streamed in real-time, published as alerts or reports, or distributed to archives.

As an example of using sensor fusion to recognize objects from multiple raw observations, consider capabilities able to recognize a particular moving object on the ground using multiple frames from a UAV-borne video camera. The shape and size of this feature might be able to be derived from multiple frames of the video, as might its speed and direction. While its color could be derived from a color camera, its temperature might be derived from an infrared imager upon the UAV or other platform. If this vehicle passes near a cluster of unattended ground sensors (UGS), a seismic sensor could determine its weight as well as potentially other properties based on certain signatures. An acoustic sensor might be able to additional properties of the vehicle based on known signatures. All of these observations add known properties of the features that aid in recognizing the object itself and perhaps its intended purpose.

Objects for Fusion. Objects that are suitable for fusion and for enhancing situation awareness can include those which are fairly persistent and exist in a geospatial feature database (e.g. streets, buildings, persons, etc.), as well as those which are highly dynamic and sensed in real time by sensors and human observers, which may be stored in geospatial databases but which may also be streamed or published as reports in real time. Relationships between objects or differences in objects over time might be used within a fusion process to enhance situation awareness. Fusion processes include entity association, aggregation and relational analysis, and identification of entity activities and their structural and functional changes in space and time.

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

People think of fusion from many perspectives. Data fusion processes can be accomplished by considering characteristics of the information:

- Spatial (e.g. mosaicing, 3D reconstruction of static objects)
- Spatial-temporal (e.g. temporal differencing)
- Multi-band (e.g. hyperspectral signatures)
- Multi-sensor
  - Same modality (e.g. video from different UAVs)
  - Different modality/multi signal (e.g. combining acoustic and seismic)
- Multi-INT or multi-agency (e.g. MASINT combined with IMINT)
- Multi-Object (e.g. an identified type of vehicle driven by a particular person)

3.2   Sensor Fusion

3.2.1   Fusion Objectives

Sensor fusion concerns how measurements are made available to a fusion processes and how the fusion processes make use of the observations to create semantically higher order entities, e.g., geographic features. The objectives for fusion in this category include:

- Discovery of sensor systems, observations, and observation processes that meet a user's immediate needs
- Determination of a sensor's capabilities and quality of measurements
- Access to sensor parameters that automatically allow software to process and geo-locate observations
- Retrieval of real-time or time-series observations in standard encodings including encoding the uncertainty of the measurement and parameters need to process the measurements.
- Tasking of sensors to acquire observations of interest

- Subscription to and publishing of alerts to be issued by sensors or sensor services based upon certain criteria
- Entity identification, classification and association.
- Processes and reference information, e.g., signatures and training data, to identify features of interest based upon the measurements.

3.2.2 Enabling Capabilities

There are certain fundamental capabilities that are essential to enabling the adequate fusion of observations, particularly if from multiple, disparate sensors. These capabilities are essential for discovery of available resources, for determination of their spatial, temporal, and semantic relationships to one another, for processing low-level data to higher-level information, and for assessing the reliability and lineage of the information.

- Precise geospatial and temporal registration of observations
- Sensor and process descriptions
  - Discovery
  - Observation lineage
  - Quality assurance
  - Processing enablement
- Observation processing (both web service and tool-based)
  - Georegistration, georectification, and regridding
  - Image and signal processing
  - Advanced spatio-temporal processing
    - Stereoscopy and oblique imagery reconstruction of 3D
    - Time differencing and change detection
  - Classification and signature matching
  - Object identification and pattern recognition
- Harmonization and interoperable encodings for disparate sensors
  - Sensors
  - Observations and signatures
  - Processes
- Semantics and models
  - Key to interoperability and discovery
  - Online, referenceable dictionary/ontology of terms
    - Observable properties
    - Sensor and process properties
    - Relationships
    - Recognized objects
- Timely discovery of highly dynamic and mobile assets, observations, and alerts
- Efficient streaming protocols for delivery of large, real-time or archived observations (e.g. JPIP/JP2, RTSP, HTTP Streaming, etc.), as well as alerts
  - Including support for on-demand geolocation and processing of streams

3.2.3 Objects from Fusion Processes

Objects resulting from the fusion processes of this fusion category include:

- Estimation of the attributes of geographic features including presence or absence

- Location and geometric shape of physical entities

- Estimation of physical and functional attributes of objects/features

- Provenance and uncertainties of the information about objects.

3.2.4   Tools, Resources and Standards

The ability to discover, access, and fuse multiple observations for the purpose of enhancing situation awareness is or will be enabled by the development, refinement, and implementation of several standards and tools. These resources include encoding for assets and data, web services for standard access to observations, sensor tasking, processing, and discovery, and software tools for processing, visualization, analysis, and decision support.

Following are technologies and standards (emerging and adopted) thought to be relevant to enabling open and interoperable fusion in this category:

- Encodings
    - Sensor and process descriptions (e.g. SensorML, CCSI)
    - Observations and signatures (e.g. O&M, NITF, TML, netCDF, HDF, etc.)
    - Tasking messages (e.g. SWE Common, ACTM, etc.)
    - Alert and event messages (e.g. SWE Common, CAP, EDXL, etc.)
- Web services
    - Asset discovery: Sensors and processes; Observations; Signatures
    - Observation and signature access (e.g. SOS, WCS, WFS, etc.)
    - Alert and event subscription (e.g. SAS, SES, etc.)
    - Tasking (e.g. SPS)
    - Observation and alert processing (e.g. WPS, BPEL)
- Clients
    - Discovery
    - Observation portrayal
    - Observation analysis
    - Observation processing
    - Decision support
- Middleware
    - Rule-based alert/event recognition and notification
    - Semantic discovery and term resolution
    - Temporal synchronization and spatial coincidence detection
    - Alert detection, observation processing, fusion processing, and asset tasking coordination

STANDARDS

The following standards (emerging and adopted) are thought to be relevant to enabling open and interoperable fusion in this category. Standards are listed below in brief with full citations in the Appendix.

- SensorML
- Observations and Measurements
- TransducerML
- Sensor Observation Service

- Sensor Alert Service
- Sensor Planning Service
- WCS
- WPS

3.3 Object/Feature Fusion

3.3.1 Fusion Objectives

Object/Feature Fusion is the processing of observations into higher order semantic features using processes for aggregating, relating, identifying, parsing, linking, and organizing information from multiple sources and includes feature processing such as generalization, conflation and change detection. Understanding and generating metadata that records the provenance (i.e., lineage, pedigree, chain of custody and processing) of the sources and the nature of feature fusion processes that have been applied to derive "value-added" information from them is critical to feature fusion services.

The objective of object/feature fusion is to improve understanding of the operational situation and assessment of potential threats and impacts by integrating multiple data formats, data models, and tools to identify, classify, associate and aggregate entities of interest (targets, features, objects, activities). Key objectives also include automation of processing and the ability to scale storage, network, and compute capabilities to suit growing data volumes and evolving analytical complexities.

3.3.2 Enabling Capabilities

The key analytical activities of object/feature fusion shown in Figure 1 are: entity association, aggregation and relational analysis, and identification of entity activities and their structural and functional changes in space and time. Enabling capabilities supporting feature fusion activities include:

- Metadata for describing provenance, quality, and uncertainty
- Data and service discovery
- Data quality / uncertainty modeling and representations
- Definition and use of common and mission-specific datasets/schemas with supporting tools for schema validation and schema mapping of datasets
- Data integration, conflation and generalization (e.g., geometries, schemas, duplicates, associations, etc)
- Spatial-Temporal-Semantic analytics (e.g., entity mapping, filtering, correlation, uncertainty modeling, simulation, visualization, etc.)
- Data models, encodings and services for geoparsing, linking, organizing and sharing of fusion sources and outputs. Parsing and linking involves automated text recognition and association to location and other entities e.g., parsing a text document that contains the word-phrase "Baghdad" in it with detailed information about the city, and linking the document (and/or just the word-phrase in it) to a feature representation for the place called "Baghdad". Organizing and sharing of fusion sources and products is accomplished using organizing constructs for tagging, categorizing, and grouping into digital structures such as folders, compound documents, or blogs for collaboration.
- Geoprocessing workflow combines two concepts to achieve its value for the consumer: 'geoprocessing' and 'workflow'. *Geo-processing* involves processing of spatially related data, which may fall into one or more of the following categories: Spatial processing, Thematic processing, Temporal processing, Metadata processing. *Workflow* involves automated or semi-automated sequencing of tasks and processing to enable standardized and repeatable business processes that can scale with demand. Workflows are typically scripted to process routinely available information but may also be triggered by external events or alerts.

- Schema for interoperable definition of rules for geoprocessing. The rules can be inspected and compared and subsequently executed on a variety of workflow processing services. Rules-based services enable configurable, specialized, and tunable processing e.g., conflation.

Three examples of Feature Fusion processes are described briefly below. These are only examples of the kinds of fusion services and approaches to feature fusion this RFI is intending to identify. Responders are encouraged to describe their unique understanding of the problem and solutions.

Conflation & Generalization

Conflation is the process of unifying multiple separate sources of data into one integrated result. Conflation may be applicable to both raster sources and vector sources. Digital representations of geospatial features (such as roads, rivers, and forests) vary between databases, and while conflation processing is akin to forming a union between databases, differences in how features are represented in each database makes forming an integrated result challenging. When features from different sources are superimposed, they will typically differ in alignment, precision, location, completeness, and potentially in geometric representation as well. Not initially visible are differences in attribution and topology. The core of the conflation process is identifying and associating the common features across multiple data sources, in spite of aforementioned challenges, reconciling the differences between them, and constructing one integrated result. The integrated result should contain: all the unique features and all the unique attributes from the sources being processed, the "best" geospatial representation of features deemed to be common, the combined attribution for features in common, and where values differ for attributes in common, the "best" value likewise must prevail as well.

Conflation capabilities may include:

- Pre-processing (transformation of schema, projection, datum, topology quality assessment, generalization or geometry simplification)
- Feature matching criteria and methods
- Preconfliction (merge/map schemas, integrate features, edge matching, etc)
- Imagery search and retrieve and image matching

Generalization and Clipping Workflow

The data reduction process shown in Figure 3 was developed to meet a use case where a user requires a small sub-set of data due to limited bandwidth or processing limitations. Data from the WFS Source database is generalized (thinned) and clipped to a specific area of interest before delivery to a user constrained by low bandwidth. This process is automated through the use of a BPEL workflow.
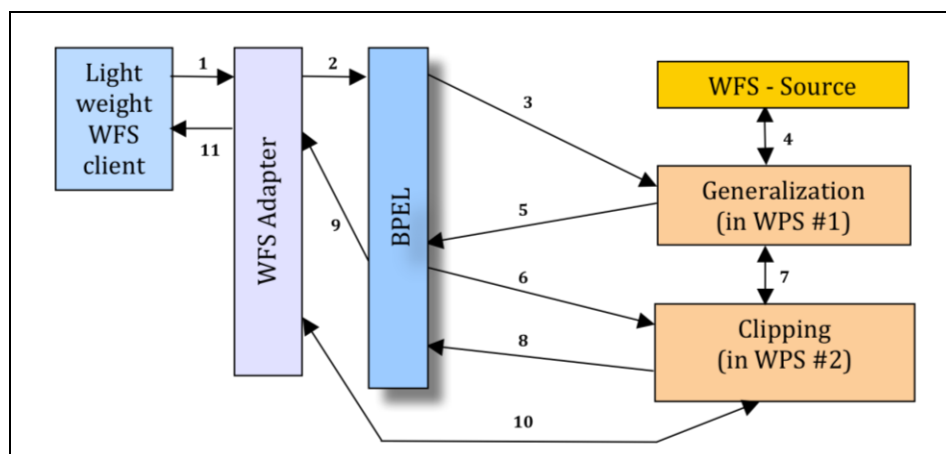

Figure 3 – Feature Fusion workflow example

Geoparser, Geocoder, Gazetteer, and Location Organizer Folder[1]

In an operational setting, the Location Organizer Client (LOC) is used by analysts to compile related sets of spatial-temporal information from multi-source information for any intelligence problems. Analysts capture and manage information in LOFs. Cooperating analysts use LOCs and supporting workflows and rules to discover, access, register, correlate and analyze information and then store and share the resulting LOFs. In the figure below, the GFS Environment consisting of applications, workflows, business rules, and services used to manage LOFs.

- Location Organizer Client (LOC) – client application that integrates multiple services for viewing, editing, discovery, analysis, publishing and collaboration.

- Location Organizer Folder (LOF) – means for storing, associating, and managing spatial-temporal resources as a geo-organized, geo-connected collection of information; a structured way to associate, organize, and share relevant information about a topic of interest.

- Geoparser - Function to scan text and discover geographic locations and related temporal information (which can then be geocoded or geolinked).

- Geocoder - Function to transform "parsed" location and event references (e.g., address, landmark) to a *location* (i.e., a feature with geometry).

- Gazetteer - Function for "looking up" geographic feature locations based on feature names.

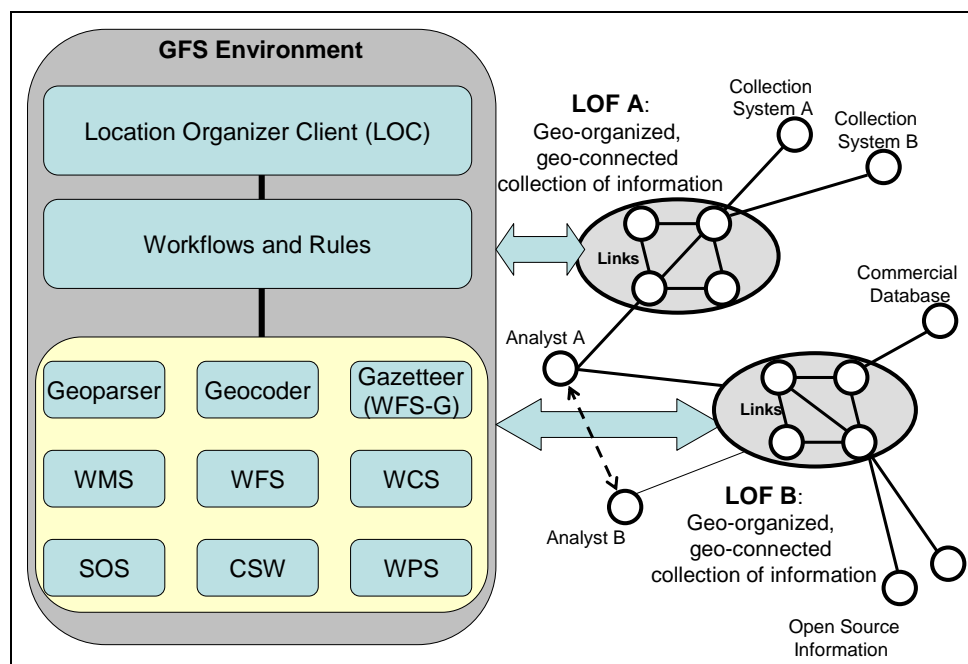**Figure 4 – A Geospatial Fusion Services environment**

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[1] The LOC, LOF – along with "geoparsing" and "geolinking",LOF, geoparser, geocoder, and gazetteer services were a construct conceived and demonstrated during OGC's Geospatial Fusion Services Testbed and Pilot initiatives in 2000-2001. A LOF is a structured way to associate, organize, and share relevant information about a topic of interest.

3.3.3   Objects from Fusion Processes

Objects resulting from the fusion processes of this fusion category include:

- Integrated datasets
- Conflated entities
- Semantically-enhanced "value-add" entities (via aggregations, associations, mappings)
- Metadata for describing provenance and uncertainty
- New actionable information

3.3.4   Tools, Resources and Standards

Following are technologies and standards (emerging and adopted) thought to be relevant to enabling open and interoperable fusion in this category. Standards are listed below in brief with full citations in the Appendix.

- Metadata: ISO19115, UnCertML
- Discovery: OGC CS, OASIS ebXML Reg/Rep
- Common Application schema and Mission-specific datasets: GML, profiles, and subsetting tools
- Data quality / uncertainty modeling and representations: UnCertML, SensorML, O&M
- Data integration/conflation: WCPS, WPS, WFS-G (Gazetteer), OLS Geocoder Service
- Spatial-Temporal-Semantic analytics: O&M, SensorML, UnCertML, Event-PatternML, OWL, WPS
- Linking, organizing, sharing: GML, GeoRSS, KML, Location Organizer Folder (LOF), Geolinking Service, Geoparser Service, Geocoder Service
- Automation and workflow: WPS, WCPS, WfCS, Wf-XML, XPDL, BPEL
- Grid and Cloud computing standards for scalable, hosted, and managed storage, network and compute infrastructures.

3.4   Decision Fusion

3.4.1   Fusion Objectives

The Decision Fusion Objectives section addresses how data sources are integrated into a fusion processes and how the fusion processes provide input to the decision making process. The objectives for fusion in this category include:

- Discovery of data (static and dynamic) resources that meet a users immediate requirements and to bring make those resources part of a fusion process under the control of the decision maker or analyst.

- Retrieval of real-time or time-series data in standard encodings that provide the ability to fuse the data into useable information based upon the users uncertainty of the measurement and parameters needed to process the data

- Determination of the quality and validity of the data and fusion products produced from the data

- Ability to fuse derived data and information with processes, policies, and constraint information as set by the data/information owners (i.e., Concept of Operations) and decision services processing nodes.

- Ability to present the derived information in a spatial client application (e.g., SLD, SE, W3D) including portrayal of maps and 3D visualization.

- Ability to collaborate with other decision makers and analysts using social networking services and collaboration tools that are location enabled. Documents that capture an analysis result and allows for distribution to others for viewing the same context.

While Sensor Fusion and Feature Fusion provide the "right data", Decision Fusion provides that information in the "right time and for the right place". Decision Fusion pulls together Sensor Fusion and Feature fusion results, combines those with additional data inputs to provide a result on which decisions or actions can be executed. Fixed and mobile sensors of many kinds, including Full Motion Video, are providing dynamic data and emerging location-based services.

3.4.2   Enabling Capabilities

The fundamental concept underlying Decision Fusion is that a decision maker is able to sit down at a single workstation, identify any resource anywhere, access that resource, bring it into their operational context, integrate it with other resources to support the decision process, and to share the resulting context with others. All of this takes place in a global enterprise made up of many different organizations and many different information communities. Each of them has their own information models and semantics as well as their own policies and procedures. Decision Fusion tools allow the decision maker to navigate this environment with minimal distraction from the issue at hand. The following graphic displays a generic view of the Decision Services Support (DSS) concept:
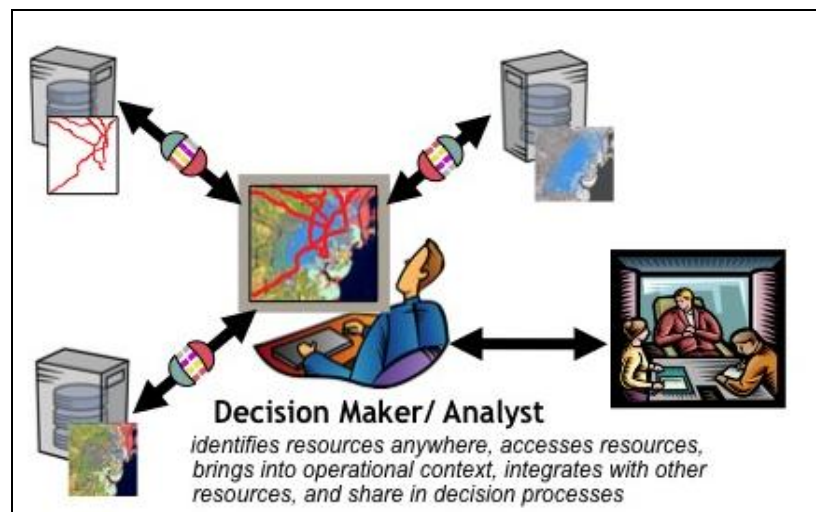
Figure 5 – Integrated Client

Integrated Client

The purpose of an integrated client is to provide a unified environment that allows a user to visualize, analyze, and/or edit data from feature, imagery, video and sensor web data sources within a single client. The integrated client allows the user to fuse information from various sources into a common view or context to convey a conclusion about a specific geographic situation and to share and collaborate the perspective. Decision fusion happens within and between client applications. Within the context of the OGC, this means that the integrated client allows a user to publish, discover, access, integrate and apply all types of spatial data (e.g., raster, vector, coverages and sensor observations) from a wide range of vendor web services through OGC standard interfaces. Multi-tool integrated client applications provide access to distributed functionality in the following categories:

- Service Discovery & Binding
- Feature Production

- Imagery Production/Exploitation

- Sensor Web Planning/Exploitation

- Project Persistence and Sharing

- Process and Policy Services
    - Portrayal of 2D/3D geospatial information
    - Utilization of emergency alerting and situational awareness updates
    - Collaboration encodings: KML, OWS Context, LOF

3D Visualization for Built Environment

A key aspect for establishing context is the visualization of an environment, including the built environment. 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.   Such information about the built environment includes

- Buildings
- Transportation infrastructure
- Utilities infrastructure
- Other physical infrastructure and their surroundings

There are many types of documents or data objects that might be referenced to the built infrastructure and natural environments. The documents and data may be items such as evacuation plans, road conditions, inventories of hazardous materials, current environment indicators and weather conditions that would be useful to be able to discover and access based on references to locations.

Information Collaboration

Decision Fusion includes collaboration of various persons in developing an understanding of a specific context. Collaboration with other decision makers and analysts can be accomplished using social networking services and collaboration tools that are location enabled. One enabling element of collaboration is encoding methods for capturing and sharing the context or picture created by one analyst to be shared with others. Several of these encoding methods are described in the following.

- Location Organizer Folder (LOF)

The Location Organizer Folder (LOF) is a GML document that provides a structure for organizing the information related to a particular event or events of interest. It may be used in various analysis applications, like disaster analysis, Intelligence analysis, etc. It is spatially enabled, and capable of managing disparate types of information.

The LOF is an information structure. There may be a variety of services external to the LOF that provide the means for generation and manipulation of the information in the structure. This includes search and discovery, parsing different resources and the extraction of useful information, assigning spatial attributes, relating (linking) resources of interest, and so on.

- OWS Context

OWS Context document is an XML encoding that references remote and/or local OGC Web Services. OWS Context is related to, but more powerful than, Web Map Context. Web Map Context specification states how a specific grouping of one or more maps from one or more WMS can be described in a portable, platform-independent format for storage in a repository or for transmission between clients. OWS Context can reference WMS and other OGC Web Services such as WFS and WCS.

- KML

KML is an XML grammar used to encode and transport representations of geographic data for display in an earth browser, such as a 3D virtual globe, 2D web browser application, or 2D mobile application. A KML instance is processed in much the same way that HTML (and XML) documents are processed by web browsers. Like HTML, KML has a tag-based structure with names and attributes used for specific display purposes.

Geospatial Fusion Engine

In an operational setting, the decision fusion services are used by analysts to compile related sets of spatial-temporal information from multi-source information for a specific context. There is a need for increasingly capable client applications or "fusion engines" that can support decision fusion as shown in Figure 6.
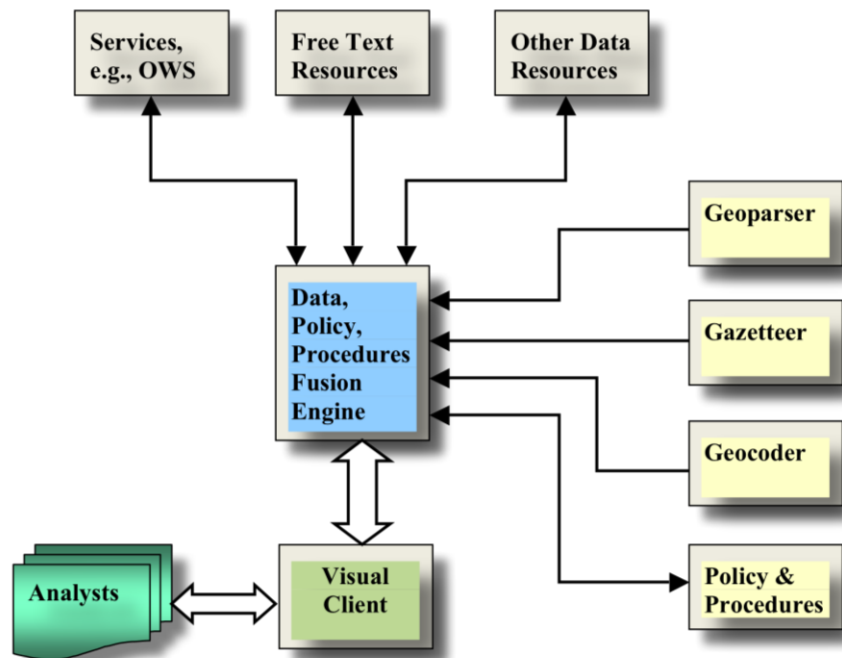
Figure 6 – Geospatial Fusion Services Client Environment

3.4.3   Objects from Fusion Processes

Objects resulting from the fusion processes of this fusion category include:

- Informed decisions based upon the data, information, policy and procedures being fused together.
- Visualize, analyze, and edit data into fusion product. This is to include SE, SLD portrayal and 3D visualization.
- Ability to publish, discover, consume and integrate spatial data (e.g., raster, vector, coverages, sensor observations) from feature, imagery, video, and sensors
- Provide interoperable access to distributed geospatial web services and data objects
- Ability to provide decision makers relevant data to aid in forming, analyzing, and selecting alternate solutions based upon dynamic situations

- Workflow management to produce context specific results from information and knowledge from multiple communities

3.4.4   Tools, Resources and Standards

Following are technologies and standards (emerging and adopted) thought to be relevant to enabling open and interoperable fusion in this category. Standards are listed below in brief with full citations in the Appendix.

- OWS-6 Decision Support Services (DSS) Engineering Report (ER)

- Metadata: ISO19115, UnCertML

- Discovery: CSW, ebRIM, SOA

- Portrayal: ISO19117, Styled Layer Descriptor (SLD) and Symbol Encoding (SE)

- Common Application schema and Mission-specific datasets: GML, profiles, and subsetting tools

- Data quality / uncertainty modeling and representations: UnCertML, SensorML, O&M

- Data integration/conflation: conflation rules, WCPS, WPS, WFS-G, OLS Geocoder,

- Spatial-Temporal-Semantic analytics: O&M, SensorML, UnCertML, Event-PatternML, OWL, WPS

- Visualizing, linking, organizing, sharing: GML, CityGML, X3D ISO/IEC 19775, VRML, GeoRSS, KML, LOF, OWS, etc

- Automation: WPS, WCPS, WfCS, Wf-XML, XPDL, BPEL

- Grid and Cloud computing standards for scalable, hosted, and managed storage, network and computing infrastructures.

3.5   Architecture for Fusion

3.5.1   Fusion Architecture Objectives

A network-centric environment with distributed databases and services based on a common core of standards-based data formats, algorithms, services, and applications allowing geospatial information (and other forms of INT) to be collected, stored, managed, fused and disseminated vertically and horizontally, from peer to peer, and from National to the Soldier level.

A fusion environment involves people, processes, data, and technology that combine functional information with information about space and time (Figure 7). This means combining information from ISR, C2, planning assets, and Multi-INT in space and time in order to assemble, relate, and coordinate relevant information from a variety of disparate sources (soldiers, systems and other assets) and to provide a common situational understanding and a cohesive set of decision solutions. The fusion architecture will facilitate system interoperability, which is the capability of components or systems to share data and services with other components or systems and to perform in multiple environments.

The discussion that follows is intended to be informative, providing an operational, technical and performance context for Fusion Services.

In the conceptual fusion environment depicted in Figure 7, there are aggregator, processor and viewer services supporting collecting and consolidating, generating and synthesizing, and viewing and filtering activities, respectively. Information flows in various raw, processed, and fused representations into the fusion environment via network linkages enabled by connections between external source nodes and interoperability nodes. Seamless and interoperable flows between aggregators, processors, viewers, workflows, and client applications occur via Interoperability Nodes within the fusion environment. Information flows with external resources often occur via translator (gateway/guard) nodes. Interoperability

Nodes and External Source Nodes may support a variety of service and encoding standards, supporting both producer and consumer interconnections.
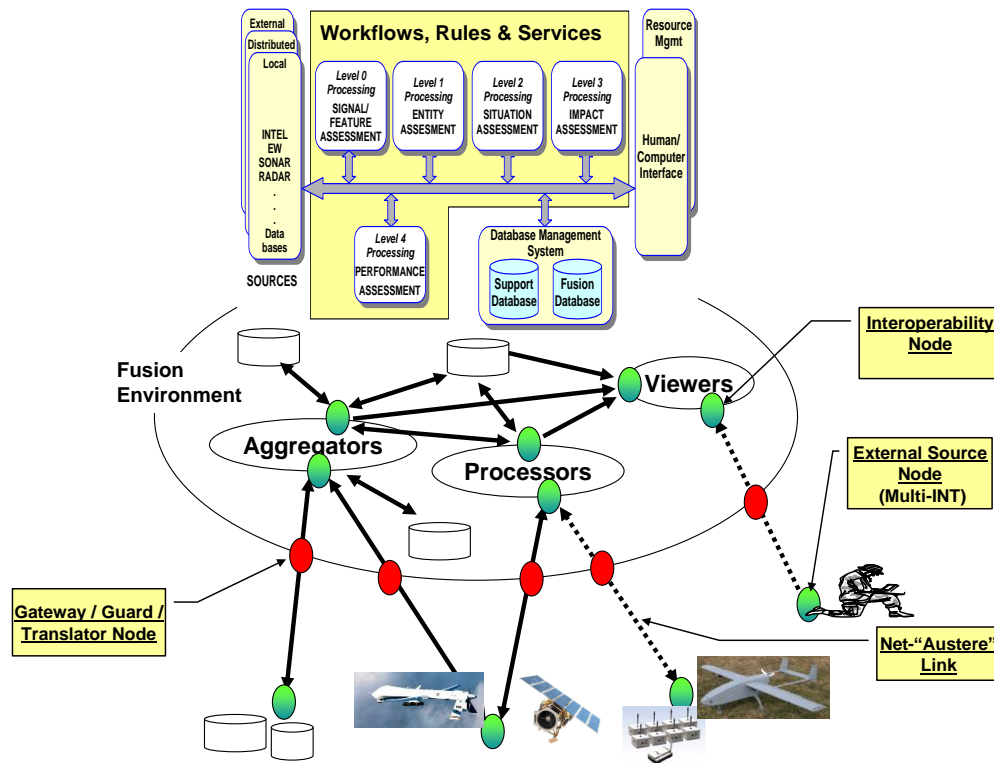
Figure 7 – Fusion Services Architecture Concept

3.5.2   Enabling Capabilities

There are certain infrastructure capabilities that are essential to enabling fusion. These capabilities are essential for distributed information systems in general, but may have particular requirements or emphasis for fusion processes. Some relevant enabling capabilities are:

- Scalable to massive data volumes and complex processing

- Streaming and caching

- Managed and hosted (distributed, off-premise)

- Automated and manage processing and workflows

- Reliable and available

- Security in distributed information systems

- Distributed, virtualized nodes made accessible and interconnected via open Web services and standards-based grid and cloud-computing infrastructures

- Scalable, reliable, cost-effective storage, network and computing capabilities for enabling fusion.

3.5.3   Tools, Resources and Standards

Following are technologies and standards (emerging and adopted) thought to be relevant to enabling open and interoperable fusion in this category[2]:

- Web Services (SOAP/REST) means to connect producers and consumers of resources (data and services)

- Security – means to enable authentication, authorization, confidentiality, and integrity of resources and interconnections

- Workflow – standardized means for automation of business processes and event processing

- Grid computing – high performance distributed computing and very large datasets

- Cloud computing – Software as a Service (SaaS) and Infrastructure as a Service (IaaS)

- Streaming and Caching – supported by standard encodings and services, including but not limited to MPEG4 (video/multi-media streaming), JPIP (JPEG2000 streaming), WMTS (Web Map Tiling Service), and advanced caching and content delivery mechanisms (see CDN below).

- Content Delivery Networks (CDN) – technology and network infrastructure for video streaming, large-volume-files downloads, and image caching, the purpose of which is to deliver improved quality of service for Internet users.

- Expeditionary infrastructure for operations in "network austere" environments with disconnected, intermittently connected and/or very low-bandwidth network communications.

3.5.4   Deployment Environments and Networks

The variety of fusion processes is deployed in a variety of environments of hardware hosts and network technologies.

Fusion capabilities are to be engineered for military and civilian expeditionary environments as well as crisis operations. Timely, relevant, actionable fusion products and services are to be accessible to warfighters, coalition and civilian partners though extensible multilevel networks, anywhere, anytime.

3.5.5   Geoprocessing Workflow

In enterprise environments, it becomes necessary to produce complex functional capabilities that are composed from a variety of existing services using workflow orchestration and choreography. These technologies have mostly focused on implementation of workflow processes in the form of a runtime execution language or script for an associated process engine. This approach provides an effective means to deploy and execute processes within a homogeneous environment served by a particular process engine. However, to meet the needs within and across enterprises that may be using different process engines and languages a more abstract approach is needed to facilitate design, integration, execution and management of these processes many of which will be asynchronous by nature.

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

Geoprocessing Workflows integrate data and services in an interoperable way, where each part of the workflow is responsible for only a specific task, without being aware of the general purpose of the workflow. Due to the distributed nature of geographic data, Geoprocessing Workflows provide flexible means of processing highly distributed and complex data for a wide variety of uses.

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[2] See also Tables A-6 and A-7 in the Appendix of this RFI.

3.5.6 Grid and Cloud Computing[3]

Highly specialized geospatial applications based on large volumes of distributed data such as live sensor data streams at different scales combined with high resolution geospatial data, which have to be analyzed in real-time for risk management issues, require often the functionality of multiple processes. In such highly specialized large-scale geospatial applications, not every processing step can potentially be handled by a single processing entity (for example with the resources of a single computer). To improve the computational performance of processing large amounts of dynamic geospatial data, Grid and Cloud computing provides appropriate tools.

Cloud computing is a pay-per-use model for enabling convenient, on-demand network access to a shared pool of configurable and reliable computing resources (e.g., networks, servers, storage, applications, services) that can be rapidly provisioned and released with minimal consumer management effort or service provider interaction.

Cloud computing infrastructures often leverage the following characteristics:

- Massive scale
- Virtualization
- Free software
- Autonomic computing
- Multi-tenancy
- Geographically distributed systems
- Advanced security technologies

To be considered a "cloud" the offered service must be deployed on top of cloud infrastructure that enables the key characteristics stated above.

3.5.7 Security-enabled Architecture for Fusion

Realization of web services security architectures and mechanisms must be robust and mature to meet the challenges facing a fusion of rich sets of data or information from a variety of disparate resources in order to improve one's capability to detect, identify, and characterize an entity for useful and timely action. Web services security is founded on the following concepts[4]:

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

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

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

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

Confidentiality: Make content unreadable by unauthorized parties. Ensure that only legitimate parties may view content, even if other access control mechanisms are bypassed, and guarantee that

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[3] See also Table A-7 for references related to Cloud and Grid.

[4] Guide to Web Services Security, NIST Special Pub 800-95, August 2007

exchanged information is protected against eavesdroppers. Confidentiality is generally associated with encryption technologies.

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

Ensuring the security of web services involves implementation of security frameworks based on use of authentication, authorization, confidentiality, and integrity mechanisms that include the following security standards.

Confidentiality - XML Encryption as a mechanism to encrypt XML documents

Integrity - XML Signature to provide a means to selectively sign XML data

Authentication and Authorization – SAML, GeoXACML, XACML and resource-oriented approaches such as OpenID and OAuth

Public Key Infrastructure (PKI) - using XKMS and X.509 Certificates

WS-Security - SOAP header extensions for end-to-end SOAP messaging security that supports message integrity and confidentiality.

4   Responding to this RFI

4.1   General Terms and Conditions

Responses to this RFI are due by the date listed in the Master Schedule. Responses will be distributed to members of the OGC Staff and OGC IP Team. Submissions will remain in the control of this group and will not be used for other purposes. A summary of the RFI Responses may be made public.

If a RFI response includes proprietary information it must be submitted in a separate document. See instructions.

4.2   How to Submit

An electronic version of your response is to be sent to the OGC Technology Desk (techdesk@opengeospatial.org) by the submission deadline. Microsoft® Word format (Office Version 2003) is preferred, however, WordPerfect®, Rich Text Format, or Adobe Portable Document Format® (PDF) are acceptable.

You are welcome to contact the Technology Office via telephone (+1 812 334 0601) to ensure receipt of your submission.

4.3   RFI Response Outline

Your RFI response should follow this outline:

1. Overview and executive summary
2. Elaboration
    3.1   Definition of Fusion
    3.2   Sensor Fusion
    3.3   Feature Fusion
    3.4   Decision Fusion
    3.5   Architecture for Fusion.
3. Organization description

The content of the "Elaboration" section should describe fusion processes that your organization sees as feasible in a distributed information environment. The description of the fusion process can be accomplished by providing requirements and use cases as well as product descriptions and capabilities. The elaboration should include identification of relevant existing standards and where new standards might be needed. Any proprietary information shall be included in a separate document.

The sub-sections of Elaboration section shall use the outline shown. Responses are not required to populate each Elaboration sub-section. If a response does not have content for a sub-section, just state "section blank in this response."

Any proprietary information must be contained is a separate document that is clearly marked as containing proprietary information.

4.4   Questions and Clarifications

An RFI Clarification Conference Call is scheduled for the date shown in the Master Schedule. To join the teleconference use this dial-in information: +1 512 225 3050 passcode: 55699#.

All questions and requests for clarification should be sent to the OGC Technology Desk (techdesk@opengeospatial.org **prior to the conference call**. Questions received by the OGC well prior to the call as well as OGC clarifications will be posted publicly at the OGC Web Site for the Fusion Standards Study within 24 hours of receipt.

We will also announce the availability of these questions and clarifications to the OGC Technical Committee electronic mail reflector. For those who are unable to attend the call, we will post a summary of the questions and clarifications addressed during the conference call the day following.

4.5   Reimbursements

The OGC will not reimburse submitters for any costs incurred in connection with preparing responses to this RFI.

4.6   Master Schedule

The following table details the major events associated with this RFI:

Fusion Standards Study	
RFI Issued	16 July 2009
RFI Clarification Conference Call	28 July 2009 – 11:00 am to Noon EDT
Clarifications Posted	31 July 2009
RFI Responses Due	12 August 2009 – 5:00 pm EDT

Appendix – References

Table A-1. Approved OGC Specifications Related to Fusion Study RFI

Title	Version
Catalog Service for the Web (CSW) with Corrigendum, profiles and extensions	2.0.2
Web Coverage Service (WCS)	1.1.2
Web Coverage Service (WCS) - Transaction Operation Extension	1.1.4
Web Coverage Service - Processing Extension (WCPS)	1.0.0
Web Feature Service (WFS)	1.1
Web Map Service (WMS)	1.3.0
Web Map Context (WMC) with Corrigendum	1.1
Web Processing Service (WPS)	1.0
Web Service Common	1.1
Geography Markup Language (GML)	3.2.1
CityGML Implementation Specification	1.0
Styled Layer Descriptor (SLD)	1.1
Symbology Encoding (SE)	1.1
Filter Encoding (FE)	1.1
Geospatial eXtensible Access Control Markup Language (GeoXACML)	1.0
KML	2.2
Open Location Services (OpenLS)	1.1
Observations and Measurements - Part 1: Observation schema	1.0
Observations and Measurements - Part 2: Sampling Features	1.0
SensorML with corrigendum	1.0.1
Sensor Observation Service	1.0
Sensor Planning Service	1.0

Table A-2. Candidate Standards Related to Fusion Study RFI

Title	Version
Web Map Tiling Service (WMTS) Candidate Standard	-

Table A-3. Approved OGC Best Practice Documents Related to Fusion Study RFI

Title	Version
Binary Extensible Markup Language (BXML) Encoding Specification (03-002r9)	-
EO Products Extension Package for ebRIM Profile of CSW 2.0	0.1.9
Gazetteer Service - Application Profile of the Web Feature Service Implementation Specification	0.9.3
GML Application Schema for EO Products	0.9.0
GML Encoding of Discrete Coverages (interleaved pattern)	0.2.0
GML PIDF-LO Geometry Shape Application Schema for use in the IETF	0.1.0
Ordering Services for Earth Observation Products	0.9.0
Sensor Alert Service	0.9.0
Sensor Planning Service Application Profile for EO Sensors	0.9.5
Sensor Web Enablement Architecture	0.4.0
Units of Measure (UoM) Recommendation	1.0.0
Web Map Services - Application Profile for EO Products	0.2.0
Web Notification Service (WNS)	0.0.9

Table A-4. Discussion Papers Related to Fusion Study RFI

Title	Version
URN namespace for the Open Geospatial Consortium (OGC)	2.0.0
Access Control & Terms of Use (ToU) "Click-through" IPR Management	1.0.0
Discussions, findings, and use of WPS in OWS-4	0.9.1
Feature Portrayal Service (05-110)	-
Feature Styling IPR	0.4.1
Frame image geopositioning metadata GML 3.2 application schema (07-032)	-
Geocoder Service Draft Candidate Implementation Specification, Discussion Paper (retired)	0.7.6
GeoDRM Engineering Viewpoint and supporting Architecture	0.9.2
GEOINT Structure Implementation Profile (GSIP) Schema Processing	0.5.0
Geolinked Data Access Service	0.9.1
Geolinking Service (GLS)	0.9.1
Geoparser Service Draft Candidate Implementation Specification, Discussion Paper (retired)	0.7.1
Geospatial Portal Reference Architecture	0.2.0
Geospatial Semantic Web Interoperability Experiment Report	0.5.0
GML Performance Investigations by CubeWerx	1.0.0
GML Point Profile	0.4.0
Imagery Metadata	1.0.0

Title	Version
Integrated Client for Multiple OGC-compliant Services	0.1.18
Location Organizer Folder (LoF) Draft Candidate Implementation Specification, Discussion Paper (retired)	1.03
Loosely Coupled Synchronization of Geographic Databases in the CGDI	0.0.9
OGC Web Services Architectural Profile for the NSG	1.3.0
OWS-3 GML Investigations - Performance Experiment by Galdos Systems	-
OWS-5 SOAP/WSDL Common Engineering Report	0.1.0
OWS Context IE Final Report (05-062) (See Note 1)	0.0.3
OWS Messaging Framework (03-029)	-
OWS-3 GML Topology Investigation (05-102r1)	-
OWS-3 Imagery Workflow Experiments: Enhanced Service Infrastructure Technology Architecture and Standards in the OWS-3 Testbed	0.9.0
OWS-3 Integrated Client (GeoDSS Client) (05-116)	-
OWS-3 UML to GML Application Schema (UGAS) Tool (05-118)	-
OWS-4 CSW ebRIM Modelling Guidelines IPR (06-155)	-
OWS-4 Web Processing Service IPR (06-182r1)	-
OWS-4 Workflow Descriptions and Lessons Learned (06-187r1)	-
OWS-5 Conflation ER (07-160r1)	-
OWS-5 Data View Architecture ER (07-163r1)	-
OWS-5 Geoprocessing Workflow Architecture ER (07-138r1)	-
OWS-5 GeoRM License Broker Specification ER (See Note 2)	0.9
OWS-5 GSIP Schema Processing ER	0.0.2
OWS-5 OGC Web Services Architectural Profile for the NSG (07-009r3)	-
OWS-5 SOAP/WSDL Common ER	0.1.0
OWS-4 Topology Quality Assessment Interoperability Program Report	0.3.0
Schema Maintenance and Tailoring (05-117)	-
Some image geometry models	1.0.0
Temporal Standard Recommendations (06-022r1)	-
Trusted Geo Services IPR	0.9.0
Uncertainty Markup Language (UncertML) (08-122r2)	0.6
Web 3D Service	0.3.0
Web Coordinate Transformation Service (WCTS)	0.4.0
Web Image Classification Service (WICS)	0.3.3
Web Object Service Implementation Specification (03-013)	-
WFS Temporal Investigation	0.1.0
WMS - Proposed Animation Service Extension	0.9.0
WMS Change Request: Support for WSDL & SOAP	0.1.0
WMS Part 2: XML for Requests using HTTP Post (02-017r1)	-
XML for Image and Map Annotation	0.4.0

Notes:

(1) Document 05-062 has not yet been approved for public release; draft may be made available upon request.

(2) Document 08-076 adoption as an OGC Discussion Paper is contingent on a modification of the document to add sufficient requirements and examples to demonstrate a license as defined by this document is always consistent with figure 5 General License Model, in OGC Document 06-004r3 GeoDRM Reference Model. Draft may be made available upon request.

Table A-5. Recently Approved OGC Discussion Papers Relevant to Fusion Study RFI

Title	Version or Doc#
OWS-6 SWE Summary Report	09-064r2
OWS-6 Georeferenceable Imagery ER	09-034
OWS-6 SWE Information Model ER	09-031r1
OWS-6 SensorML CR	08-192r1
OWS-6 SensorML Profile for Discovery ER	09-033
OWS-6 Secure Sensor Web ER	08-176r1
OWS-6 SWE CCSI ER	09-007
OWS-6 Event Architecture ER	09-032
OWS-6 SWE PulseNet (rm) ER	09-073
OWS-6 GPW Summary ER	09-063
OWS-6 Security ER (See Note 3)	09-035
OWS-6 GeoXACML ER	09-036r1
OWS-6 Urban Topographic Data Store (UTDS) - CityGML Implementation Profile ER	09-037r1
OWS-6 CityGML CR	09-039
OWS-6 GML Profile Validation Tool Guidelines ER	09-038r1
OWS-6 WPS - Grid Processing ER	09-041r2
OWS-6 GeoProcessing Workflow Architecture ER	09-053r3
OWS-6 DSS Summary Engineering Report	09-068r1
OWS-6 WMS-Tiling ER	09-006
OWS-6 Symbology-Encoding Harmonization ER	09-012
OWS-6 Symbology Encoding (SE) CR	09-014
OWS-6 Symbology Encoding (SE) Changes ER	09-016
OWS-6 Styled Layer Descriptor (SLD) CR	09-013
OWS-6 Styled Layer Descriptor (SLD) Changes ER	09-015
OWS-6 W3DS - 3D Flythrough ER	09-075r1
OWS-6 Outdoor and Indoor 3D Routing Services ER	09-067

Title	Version or Doc#
WCS Change Request to Support Error Propagation	09-099

Notes:

(3) Document 09-035 still in revision; draft may be made available upon request.

Table A-6. Non-OGC Standards Related to Fusion Study RFI

Name	Specification	Description
WSDL	Web Services Description Language v 2.0 W3C Recommendation http://www.w3.org/TR/wsdl20/	Web Services Description Language (WSDL) is a specification from W3C to describe networked services. WSDL is used to describe what a web service can do, where it resides, and how to invoke it. It provides a simple way for service providers to describe the basic format of requests to their systems.
SOAP	Simple Object Access Protocol (SOAP) 1.1 http://www.w3.org/TR/soap11/ ; SOAP 1.2 http://www.w3.org/TR/soap/	Simple Object Access Protocol (SOAP) is a protocol specification from W3C for exchange of information in a decentralized, distributed environment.
BPEL	Web Services Business Process Execution Language 2.0 – OASIS Standard http://docs.oasis-open.org/wsbpel/2.0/wsbpel-v2.0.html	The Business Process Execution Language for Web Services (BPEL4WS or BPEL for short) defines a notation for specifying business process behavior based on Web Services.
ebXML	OASIS Standard 2.0 http://www.oasis-open.org/specs/index.php#ebxmlbp2.0.4 , see also ISO/TS 15000-5:2005	Defines a standards-based business process foundation that promotes the automation and predictable exchange of Business Collaboration definitions using XML.
ebXML RIM	ebXML Registry Information Model 2.0 – OASIS Standard http://www.oasis-open.org/committees/regrep/documents/2.0/specs/ebrim.pdf	Defines what information is in the Registry and how that information is organized. This leverages as much as possible the work done in the OASIS and the ISO 11179 Registry models.
Wf-XML	Workflow-XML 1.1 and 2.0 - Workflow Management Coalition (WfMC) Standard http://www.wfmc.org/standards/wfxml.htm	Wf-XML is designed and implemented as an extension to the OASIS Asynchronous Service Access Protocol (ASAP). ASAP provides a standardized way that a program can start and monitor a program that might take a long time to complete. Wf-XML provides additional standard web service operations that allow sending and retrieving the "program" or definition of the service which is provided. Wf-XML is an ideal way for a BPM engine to invoke a process in another BPM engine, and to wait for it to completed.
Wf-XML-R	Workflow-XML (RESTful Binding) Draft 0.4 - WfMC Standard http://www.wfmc.org	

Name	Specification	Description
XPDL	XML Process Definition Language 2.1 – WfMC Standard http://www.wfmc.org/standards/xpdl.htm	XPDL provides a file format that supports every aspect of the BPMN process definition notation including graphical descriptions of the diagram, as well as executable properties used at run time.
WS-Security	Web Services Security 1.1 – OASIS Standard http://www.oasis-open.org/committees/download.php/16790/wss-v1.1-spec-os-SOAPMessageSecurity.pdf	This specification and associated token profiles (Username, X.509, SAML, Kerberos, REL, and SOAP with Attachments) provide the technical foundation for implementing security functions such as integrity and confidentiality in messages implementing higher-level Web services applications.
SAML	Security Assertion Markup Language 1.1 – OASIS Standard http://www.oasis-open.org/specs/index.php#samlv1.1 SAML 2.0 – OASIS Standard http://www.oasis-open.org/specs/#samlv2.0	This specification defines the syntax and semantics for XML-encoded assertions about authentication, attributes, and authorization, and for the protocols that convey this information.
XACML	eXtensible Access Control Markup Language 2.0 – OASIS Standard http://www.oasis-open.org/specs/#xacmlv2.0	This specification, together with associated schemas and resource profiles, defines the syntax and semantics for access control.
XML Signature	W3C Recommendation http://www.w3.org/TR/xmldsig-core/	Specifies XML digital signature processing rules and syntax. XML Signatures provide integrity, message authentication, and/or signer authentication services for data of any type, whether located within the XML that includes the signature or elsewhere.
XML Encryption	W3C Recommendation http://www.w3.org/TR/xmlenc-core/	Specifies a process for encrypting data and representing the result in XML. The data may be arbitrary data (including an XML document), an XML element, or XML element content.
PKI	Public Key Infrastructure – IETF Standard http://www.ietf.org/html.charters/pkix-charter.html	Internet standards to support X.509-based Public Key Infrastructures (PKI) for data encryption.
XKMS	XML Key Management System – W3C Note http://www.w3.org/TR/xkms/	Specifies protocols for distributing and registering public keys, suitable for use in conjunction with the proposed standard for XML Signature. This document is a NOTE made available by the W3C for discussion only.
RSS 2.0	Web syndication system http://www.rssboard.org/rss-specification	RSS is a family of Web feed formats to publish frequently updated content.
Atom 1.0	Atom Syndication Format is IETF RFC 4287 http://tools.ietf.org/html/rfc4287 while Atom Publishing Protocol is IETF RFC 5023 http://tools.ietf.org/html/rfc5023	Alternative to RSS to ease the development of applications with web syndication feeds.
GeoRSS GML	Geographically Encoded Objects for RSS Feeds as GML Application Schema, http://georss.org/gml	Encoding of GeoRSS' objects in a simple GML version 3.1.1 profile. Compatible with RSS and Atom.

Name	Specification	Description
ISO 19117:2005	ISO TC211 Document n1578 http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=40395	Geographic Information - Portrayal
ISO/IEC 21000-5: 2004/Amd 2:2007	Rights Expression Language, REL http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=44341	ISO/IEC 21000-5:2004 specifies the syntax and semantics of a Rights Expression Language.
ISO/IEC 15408: 2005	Part 1 - http://standards.iso.org/ittf/PubliclyAvailableStandards/c040612_ISO_IEC_15408-1_2005(E).zip ; Part 2 - http://standards.iso.org/ittf/PubliclyAvailableStandards/c040613_ISO_IEC_15408-2_2005(E).zip ; Part 3 - http://standards.iso.org/ittf/PubliclyAvailableStandards/c040614_ISO_IEC_15408-3_2005(E).zip	Information technology – Security techniques – Evaluation criteria for IT security.
ISO/IEC TR15443: 2005	Information technology -- Security techniques -- A framework for IT security assurance http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=39733	Technical Report to guide the IT security professional in the selection of an appropriate assurance method when specifying, selecting, or deploying a security service, product, or environmental factor such as an organization or personnel.
ISO/IEC 10181: 1996	ISO catalogue link for ordering: http://www.iso.org/iso/search.htm?qt=10181&published=on&active_tab=standards	Security Framework for Open Systems; Part 1-Overview, Part 2-Authentication framework, Part 3-Access control framework, Part 4-Non-repudiation framework, Part 5-Confidentiality framework, Part 6-Integrity framework, Part 7-Security audit and alarms
ISO 19134	ISO/TC211 N2045, 2006-07-17 – Geographic Information – Location based services – Multimodal routing and navigation	This International Standard provides a conceptual schema for describing the data and services needed to support routing and navigation application for mobile clients who intend to reach a target position using two or more modes of transportation.
INFOD	www.ogf.org	Open Grid Forum (OGF) specification for metadata registry system for use in grid computing.
CSM TRD	Community Sensor Model (CSM) Technical Requirements Document (TRD) from Community Sensor Model Working Group (CSMWG), http://www.csmwg.seicorp.com/CSM2Doc.htm	The CSM Program will provide Government and Industry with the capability to create and maintain a standard program for developing, testing, and evaluating a collection of current and future sensor models. The models support Sensor Exploitation Tools (SETs) and other application tools that require a precise understanding of the image (data) and ground coordinate relationships. The CSMs are dynamically linked (or loaded) libraries that do not require re-compilation of the SET.

Table A-7. Grid/Cloud References Related to Fusion Study RFI

Reference	Description
http://forge.gridforum.org/sf/projects/ogsa-hpcp-wg	High Performance Computing Profile Working Group
http://ogf.org/hpcp/	OGF High Performance Computing (HPC) Basic Profile
http://ogf.org/hpcp/specs.php	OGF HPC Basic Profile Related Specs
http://portal.opengeospatial.org/files/?artifact_id=34410	OGF-OGC_2_Overview_Lee.ppt
http://portal.opengeospatial.org/files/?artifact_id=34411	OGF-OGC_3_Research_Agenda_Baranski.ppt
http://portal.opengeospatial.org/files/?artifact_id=34419	OGF-OGC_7_Grid_SDI_Kiehle.pdf

Additional Grid/Cloud related publications:

[1]   Baranski, B. (2008). Grid Computing Enabled Web Processing Service. GI-Days 2008, Münster, Germany.

[2]   Kiehle, C., Greve, K. & C. Heier (2007). Requirements for Next Generation Spatial Data Infrastructures - Standardized Web Based Geoprocessing and Web Service Orchestration. In: Transactions in GIS. 11(6), p. 819-834.

[3]   Di, L., Chen, A., Yang W., & Zhao, P. (2003). The Integration of Grid Technology with OGC Web Services (OWS) in NWGISS for NASA EOS Data . GGF8 & HPDC12. 24 – 27 June at Seattle.

[4]   Woolf, A (2006). Wrappers, portlets, resource-orientation and OGC in Earth-System Science Grids, Grid ad-hoc, OGC TC Edinburgh, June 2006 [http://portal.opengeospatial.org/files/?artifact_id=15966]