



**Request for Information (RFI)
for
Decision Fusion Standards Study**

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ABSTRACT

The Open Geospatial Consortium (OGC®) issues this Request for Information (RFI) to solicit industry input into the second phase of a Fusion Standards Study. Phase 2 of the study focuses on Decision Fusion to influence planning for OGC Web Services, Phase 8 (OWS-8) Testbed. OGC also seeks to establish alliances with other Standards Development Organizations (SDOs) having technology relevant to fusion.

This RFI is part of a second phase of the Fusion Standards Study that is focused on Decision Fusion. All categories of fusion were considered in part 1. In the context of this RFI, Fusion is defined as “the act or process of combining or associating data or information regarding one or more entities considered in an explicit or implicit knowledge framework to improve one’s capability (or provide a new capability) for detection, identification, or characterization of that entity”.

Decision Fusion, as described in the RFI, provides analysts an environment of interoperable services for situation assessment, impact assessment and decision support, based on information from multiple sensors and databases, e.g., multi-INT sources. The study includes recent advances such as social networking for decision fusion. Though the focus of the study is on military intelligence (“INT”), decision fusion is relevant to business intelligence, urban planning, and many other domains.

This study considers information technology standards – for data and services – supporting situations characterized by information from multi-sources of intelligence; some highly structured, others highly unstructured and open; where the situations include the need for analysis and decision in an ambiguous and possibly urgent environment based on partially complete assessment of the situation.

This RFI is based on requirements and contributions from OGC Member organizations – in particular the National Geospatial-intelligence Agency (NGA) – and industry recommendations from Phase 1 of the Fusion Standards Study.

Responses to the RFI should describe decision 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 June 11, 2010. 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 decision fusion for many areas including intelligence and emergency response. The RFI includes many functional areas with an emphasis on geospatial fusion. This is phase 2 of the OGC Fusion Standards Study. Information contained in RFI Responses will be used in the planning of future activities including the OWS-8 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 based on requirements and contributions from OGC Member organizations – in particular the National Geospatial-intelligence Agency (NGA) – and industry recommendations from Phase 1 of the Fusion Standards Study.

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 Objectives from the NGA InnoVision R&D Portfolio: 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 study considers information technology standards – for data and services – supporting situations characterized by information from multi-sources of intelligence; some highly structured, others highly unstructured and open; were the situations include the need for analysis and decision in an ambiguous and possibly urgent environment based on partially complete assessment of the situation.

Previous studies of fusion process have identified a need for standards:

“Developing a system that utilizes existing or developmental data fusion technology requires a standard method for specifying data fusion processing and control functions, interfaces, and associated data bases. The lack of common engineering standards for data fusion systems has been a major impediment to integration and re-use of available technology.” [Steinberg, Bowman, & White, 1999]¹

The OGC Reference Model provides a discussion of the benefits of open standards along with several examples. [OGC, 2008]

¹ References are listed in the bibliography at the end of this document

3 Decision Fusion Description

3.1 Objectives of a Decision Fusion Enterprise

3.1.1 Decision Fusion Defined

A result of the OGC Fusion Standards Study, Phase 1 was this definition of Fusion:

“Fusion is the act or process of combining or associating data or information regarding one or more entities considered in an explicit or implicit knowledge framework to improve one’s capability (or provide a new capability) for detection, identification, or characterization of that entity” [OGC, 2009].

Fusion as defined and consider in this study can be achieved now in multiple closed architectures with existing single provider software and hardware solutions. Fusion is not a new topic. The problem addressed by this study is to move those capabilities into a distributed architecture based upon open standards including standards for security, authorization, and rights management.

In Phase 1 of this Study, three categories of Fusion were defined and used to organize the study: 1) Sensor Fusion, 2) Object/Feature Fusion, and 3) Decision Fusion. Analysis and recommendations for each of the three categories along with architectural recommendations were provided in the Phase 1 Engineering Report [OGC, 2009]. A recommendation of Phase 1 was that Decision Fusion should be the topic of a second phase of the study.

In Phase 2 of this Study, the focus is on Decision Fusion, in order to provide 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 from one client. Decision Fusion includes the use of information from multiple communities, e.g., multi-INT, in order to assess a situation, and to collaborate with a common operational picture. More detailed description of the decision fusion process, e.g., the JDL and OODA models, is provided in Section 3.2.1. This study will also consider more recent advances such as social networking that can support decision fusion. . Though the focus of the study is on military intelligence (“INT”), decision fusion is relevant to business intelligence, urban planning, and many other domains.

An initial definition of decision fusion for use in this study is:

Decision fusion is the act or process of supporting a human’s ability to make a decision by providing an environment of interoperable network services for situation assessment, impact assessment and decision support, using information from multiple sensors, processed information, e.g., multi-INT sources.

The objectives for decision fusion identified in the OGC Fusion Standards Study Part 1 Engineering Report (ER) include:

- Discovery of data (static and dynamic) resources that meet a users immediate requirements and to make those resources part of a fusion process under the control of the decision maker or analyst.
- Retrieval of real-time or time-series data in standard encodings that provide the ability to fuse the data into useable information based upon the users uncertainty of the measurement and parameters needed to process the data
- Determination of the quality and validity of the data and fusion products produced from the data

- Ability to fuse derived data and information with processes, policies, and constraint information as set by the data/information owners (i.e., Concept of Operations) and decision services processing nodes.
- Ability to present the derived information in a spatial client application (e.g., OGC Style Layer Descriptor (SLD) and Symbol Encoding (SE) standards; and OGC Web 3-D Service (W3DS) discussion paper) 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.

3.1.2 Decision Fusion Node

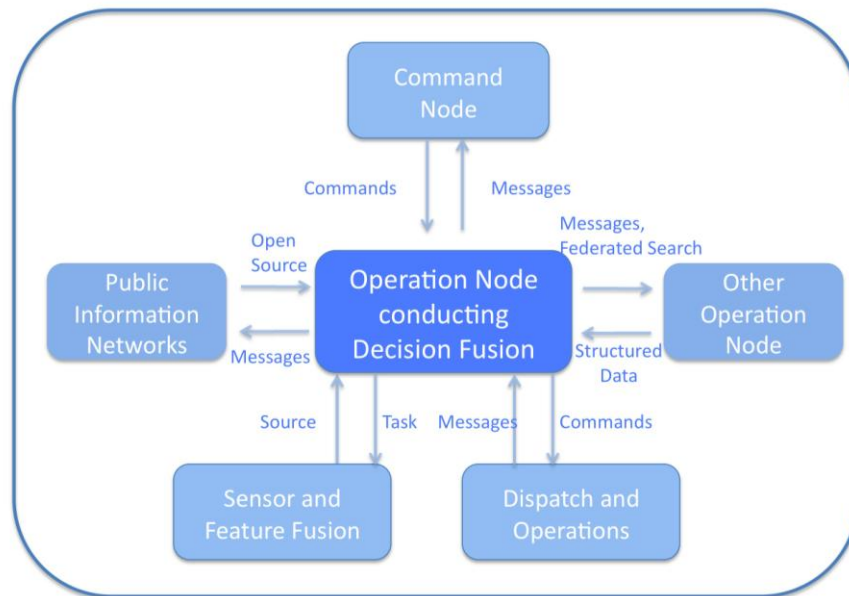
To structure the context, this study defines an “operations node conducting decision fusion”. The external interfaces for such a Decision Fusion Node are shown in Figure 1. Descriptions of each arrow on the context diagram are provided in Table 1.

The Decision Fusion Node defined in this study is a scalable concept ranging from a person with a mobile computer to a Fusion Center such as the centers identified in the US ODNI Analytic Transformation [ODNI, 2008] and the Information Sharing Environment (ISE) Fusion Centers as operated by the US Department of Homeland Security [DoJ Global, 2008].

The Decision Fusion Node described in this section is intended to apply to a wide variety of situations ranging from local to international operations; from civilian emergency response to military command and control. Implicit in the concept of the Decision Fusion Node is the collaboration with other nodes, e.g., distributed decision fusion.

Functions of a Decision Fusion Node are those steps necessary to perform a fusion process [DoJ Global, 2008], [ODNI, 2008], [Randol, 2009]:

1. **Information collection** and recognition of indicators and warnings
2. **Situation Assessment:** Processing and collation of information
3. **Impact Assessment and Decision:** Analysis and decision
4. **Information dissemination:** to associated nodes and to public networks
5. **Process Refinement**, including planning and requirements development

**Figure 1 – Decision Fusion Node Context Diagram****Table 1 – Decision Fusion Node Information Flows**

Information Flow	Description of Information Flow in Figure 1
<i>Commands</i> from Command Nodes	Structured information on which the Decision Fusion Node is to act.
<i>Messages</i> to Command Nodes	Structure information resulting from Fusion activities at the Decision Fusion Node
<i>Open Source</i> from Public Information Nodes	Collection of Unstructured Information by Decision Fusion Node from the open internet (or through a Open Source collection node)
<i>Messages</i> to Public Information Nodes	Structured messages, e.g., alerts, posted by the Decision Fusion Node to the public. Messages may be targeted to a specific public category, e.g., based on location.
<i>Source</i> from Sensor and Feature Fusion	Structured information resulting from fusion of sensor observations and object/feature processing (See Fusion Study Phase 1 ER)
<i>Task</i> to Sensor and Feature Fusion	Structured messages requesting observations or collection of information including request for fusion processing.
<i>Commands</i> to Dispatch and Operations	Structured information directing an activity to be conducted by Dispatch and Operations.
<i>Messages</i> from Dispatch and Operations	Structured information reporting on the status of activity by Dispatch and Operations.
<i>Federated Search</i> to Other Operations Nodes	Search requests to an operation node recognized by the Decision Fusion Node
<i>Messages</i> to Other Operations Nodes	Structured information transmitted to an operation node recognized by the Decision Fusion Node
<i>Structured Data</i> from Other Operations Nodes	Structured information received from an operation node recognized by the Decision Fusion Node

3.1.3 Enterprise Scenarios

Enterprise scenarios will be developed during the Fusion Standards Study. This RFI contains two scenario concepts in the following sections.

Each of the studies will include a geographic information component.

3.1.3.1 Scenario: Connecting the Dots

This scenario considers connecting information held by several Decision Fusion Nodes in the determination of a plan of attack by an individual or small group.

This scenario is motivated by the “Christmas Day Attack” of 2009 when a terrorist onboard a flight bound for Detroit attempted to ignite a bomb attached to his body. Lessons learned from the attack included [Travers, 2010]:

- This incident does not raise major information sharing issues. The key derogatory information was widely shared across the U.S. Counterterrorism Community. The “dots” simply were not connected.
- The U.S. Government needs to improve its overall ability to piece together partial, fragmentary information from multiple collectors. This requirement gets beyond watchlisting support, and is a very complicated challenge involving both numbers of analysts and the use of technology to correlate vast amounts of information housed in multiple agencies and systems.

This scenario also considers the Nationwide SAR Initiative (NSI) that is designed to increase the amount of information—the intelligence “dots”—that will flow from state, local, and tribal law enforcement agencies to the federal government. The goal of “connecting the dots” becomes more difficult when there is an increasingly large volume of “dots” to sift through and analyze. [Randol, 2009]

3.1.3.2 Scenario: Human presence detection through Multi-INT

Prior to committing personnel to investigate a building or suspicious site such as a cave, it is imperative to determine the importance and current danger of the site. This scenario aims to integrate information from multiple sources, i.e., multi-INT. The scenario will involve fusing information from sensors with cultural and human information about the area, and recent intelligence reports from human observers. [Thyagaraju Damarla, 2007], [ODNI, 2010]

This scenario will consider observing and characterizing the “human landscape” or “human terrain.” The scenario will also include quantification of the uncertainty and provenance in the decision fusion.

3.2 Information for Decision Fusion

3.2.1 Fusion Process Models

3.2.1.1 Introduction

Fusion is the processing of several elements of information into resulting novel information. While some of the information can be anticipated to conform to structures defined by a community of practice, e.g., feature catalogues, other information is relatively free of any strict organizational rules, e.g., Internet blogs, chat. To be most effective, Decision Fusion must deal with information from multiple sources – multi-INT. Thus this Information for Decision Fusion section contains three sections: 1) Fusion Process Models, 2) Structured Information, and 3) Unstructured information.

A relatively straightforward model of fusion considers spatial, temporal, and semantic objects (Figure 2) [Solano & Tanik, 2008]. Processing of spatial, temporal, and semantic attributes of multi-source object metadata results in situation assessment. On the basis of a situation assessment an analysis of threats can be conducted. Solano and Tanik define an extension to the ISO 19115 metadata standard to capture the necessary metadata for a fusion framework which implements the Joint Directors of Laboratories (JDL) Data-fusion model.

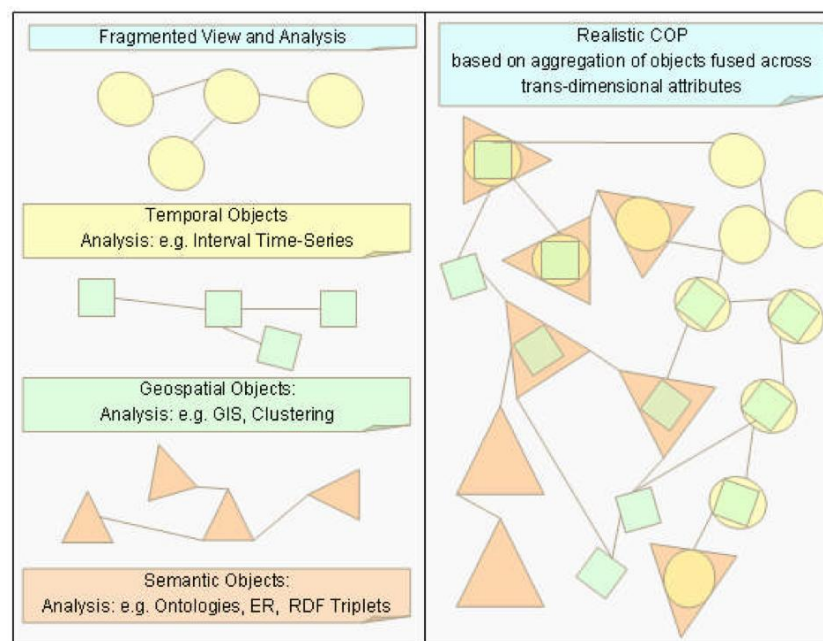


Figure 2 – Basic fusion model

3.2.1.2 JDL Fusion Model

The JDL Fusion Model has a rich history of discussion (see for example [Eloui Bosse, 2007]). A revision of the JDL Model by [Steinberg, Bowman, & White, 1999] depicts typical information flow across the data fusion “levels.” The JDL model overlaps with topics addressed in the OGC Fusion Standards Study Part 1 [OGC, 2009]. JDL Level 0 and Level 1 correspond to the Sensor Fusion and Object/Feature Fusion in the Part 1 Study. JDL Levels 2, 3, and 4 are relevant to Decision Fusion as consider in this part 2 of the Study.

- **Situation Assessment** (Level 2): Perception of environmental elements within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future. [Wikipedia, 2010]
- **Impact Assessment** (Level 3): process for considering the implications, for people and their environment, of proposed actions while there is still an opportunity to modify (or, if appropriate, abandon) the proposals. It is applied at all levels of decision-making, from policies to specific projects. [IAIA, 2010]
- **Process Refinement** (an element of Resource Management) (Level 4): adaptive data acquisition and processing to support mission objectives. [Steinberg, Bowman, & White, 1999]

The terms situation awareness and Common Operating Picture (COP) are often conflated. Situation awareness is the combined product of perception, comprehension, and projection. COP is a combination of products of psychology, technology and integration processes. The conclusion of [Eloi Bosse, 2007] is that COP provides only a partial full situation awareness.

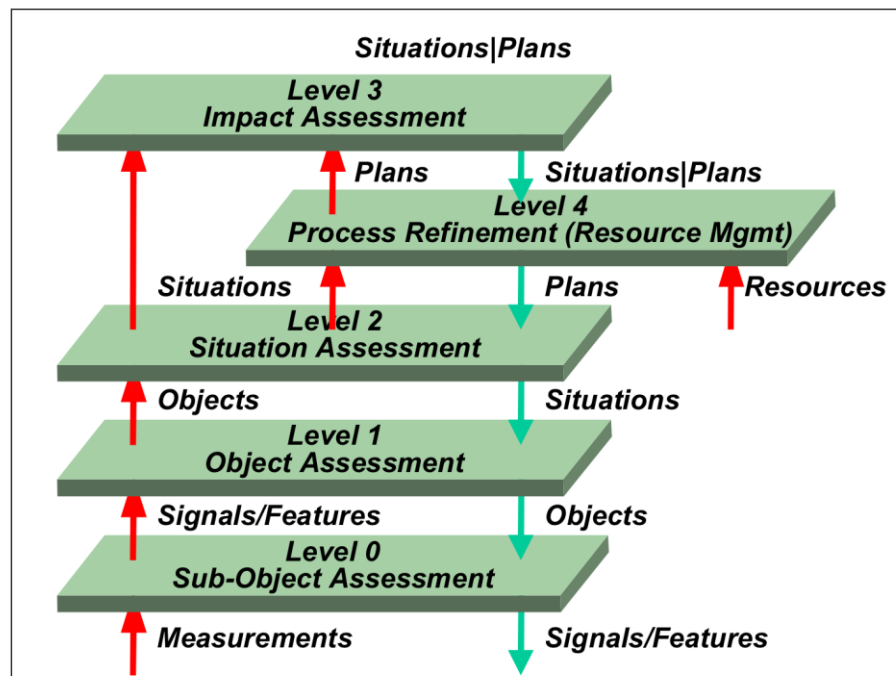


Figure 3 – Refined JDL Data Fusion Model

3.2.1.3 Decision Models

Once Situation Assessment and Impact Assessment is accomplished, an operations node is well poised to consider decision and action. Again there is a rich history of research on decision-making models (See for example [Das, 2008]).

Decision-making involves both automated and person-in-the-loop perspectives. A model combining both perspectives based on the Observe-Orient-Decide-Act (OODA) cycle is shown in Figure 4 [Lars Niklasson, 2008]. Niklasson, et.al., apply the unified model to a variety of degrees of automation. The model is used to discuss important concepts such as common operational picture and common situation awareness.

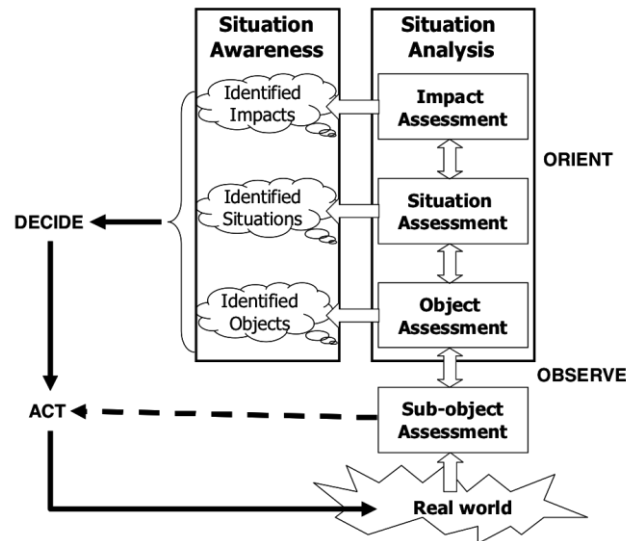


Figure 4 – Combining OODA loop with JDL levels

Decision fusion can be seen as the top of the information pyramid both in terms of information consumption and in terms of generating requests for new information. As Galdos identified [OGC, 2009], “Decision making is about making choices amongst alternatives (decision tree). It should be noted, however, that the set of choices might be quite dynamic and evolve in the course of an event (i.e. driven by the evolution of the event), or in an event independent manner. Decision makers want to learn from past mistakes (and are often also liable for their actions) hence the ability to automatically maintain an audit trail of decisions and their connection to particular feature and sensor information is critical.”

The OGC Fusion Study, Part 1 recommended that an information model be developed treating “Decision” as a first class object. The model needs to be done at abstract and implementation levels. The abstract model should define the attributes, operations and associations of a decision. For example a decision object should include an aggregation with decision trees, policies and audit trail. The decision object should include geospatial data and non-geospatial data. This abstract decision object should then be tested with real decisions from routine operational settings. Realizations of the decision should be made so that decision types can be used in registry and encodings defined for exchange.

3.2.1.4 Multi-INT information

Information available to an operations node is not just multi-source, but is from multiple intelligence collection types (multi-INT). Intelligence sources are people, documents, equipment, or technical sensors, and can be grouped according to intelligence disciplines (Table 2).

Table 2 – Multi-INT Sources [Joint Chiefs of Staff, 2007]

- Human intelligence (HUMINT);
- Geospatial intelligence (GEOINT), including Imagery Intelligence
- Signals intelligence (SIGINT);
- Measurement and signature intelligence (MASINT);
- Open-source intelligence (OSINT);
- Technical intelligence (TECHINT);
- Counterintelligence (CI).

Open source intelligence (OSINT) is a form of intelligence collection management that involves finding, selecting, and acquiring information from publicly available sources and analyzing it to produce actionable intelligence. In the intelligence community (IC), the term "open" refers to overt, publicly available sources (as opposed to covert or classified sources); it is not related to open-source software or public intelligence.

Examples of multi-INT for an urban situation are shown in Figure 5. [Marco A. Pravia, 2008]. Information elements are placed in the table according to generating source (header row) and classification between hard and soft information (below and above the diagonal, respectively).

HUMINT	OSINT	SIGINT	GEOINT	MASINT
tips	political climate	intercepted audio, imagery or video		
informant reports	population sentiment			
patrol debriefs	culture			
links and relationships	TV/radio broadcasts			
	websites			
		signal frequency	video and imagery	seismic, magnetic, chemical, and other physical signatures
		signal location	spatial extent	identification
			vehicle and building locations	event occurrence
coordinates	coordinates			radar detections

Figure 5 – Multi-INT examples for an urban situation

Consideration of multi-INT in fusion is a basis for two major trends data fusion related to “soft” fusion. [Hall, 2008]

- First, the entities that we are interested in are no longer exclusively physical and may include events, patterns and activities. We are becoming interested in the location, identity, and interactions of individuals and groups (social networks).

- The second major trend in information fusion is the emergence of two new categories of information that have previously been relatively neglected; human observations and web-based information. With the advent of ubiquitous cell phones, personal data devices (PDAs) and mobile computing devices (with associated GPS, image sensors and on-board computing), we can consider formal and informal “communities of observers” that provide information about an evolving situation.

3.2.2 Structured Information

Having discussed several models for fusion, the information used in those models is now considered in two broad categories: structured information, and unstructured information. Here structured information is defined to conform to structures, e.g., standards, defined by a community of practice. The communities of practice are inspired by the intelligence communities listed in Table 2. After identifying information standards relevant to the communities of practice, standards relevant to all communities are presented.

3.2.2.1 Geographic and Imagery Information Standards

Standards for geographic and imagery information directly relevant to decision include the following:

- OGC Geography Markup Language (GML) Implementation Specification
 - Also published as ISO 19136:2007 - Geography Markup Language
 - Multiple GML profiles and applications schemas have been defined.
- OGC CityGML Implementation Specification
- OGC Symbology Encoding (SE) Implementation Specification
- OGC Geospatial eXtensible Access Control Markup Language (GeoXACML) Implementation Specification
- OGC KML Implementation Specification
- OGC GeoPDF Encoding Best Practice
- OWS-5 GEOINT Structure Implementation Profile (GSIP) Schema Processing Engineering Report
- OWS-5 Data View Architecture Engineering Report
- OWS-6 Urban Topographic Data Store (UTDS) - CityGML Implementation Profile ER
- ISO 19109:2005 – Geographic Information – Rules for application schema
- ISO 19115:2003 – Geographic Information – Metadata
 - 19115-2:2009 – Geographic Information – Metadata - Part 2: Extensions for imagery and gridded data
 - ISO 19139:2007 – Geographic Information – Metadata - XML schema implementation
- 19153 – Geographic Information – Geospatial Digital Rights Management Reference Model (GeoDRM RM)
- NATO Ground Moving Target Indicator Format (GMTIF)
- Imagery encoding specifications: NITF, GeoPDF, GeoTIFF, HDF, NetCDF, LAS, SensorML, SWE Common

3.2.2.2 Human Reported Information Standards

Standards for human reporting of information directly relevant to decision include the following:

- OASIS Common Alerting Protocol (CAP)
- OASIS Emergency Data Exchange Language (EDXL)
- OGC Event Pattern Markup Language (EML)
- NATO STANAG 2022 "Intelligence Reports"
- ISE Suspicious Activity Reports (SAR) (Government program specification)
- National Information Exchange Model (NIEM) (Government program specification)
- Army SALUTE reporting guidelines, 301-371-1000 (SL1) - Report Intelligence Information Standards

3.2.2.3 Signals intelligence standards

Standards for signals intelligence (SIGINT) directly relevant to decision include standards for: alerts for tactically significant events and SIGINT identity information

3.2.2.4 Measurement and signature intelligence standards

Standards for measurement and signature intelligence information (MASINT) directly relevant to decision include standards for: alerts for tactically significant events and MASINT identity information

3.2.2.5 Political geography

The increasing interest in observing and characterizing the "human landscape" or "human terrain" using both conventional and emerging information sources motivated the assessment of technologies related to understanding and modeling the new domains. [InnoVision, 2009]

Standards are needed for sharing of information in these key sub-areas: (1) human landscape modeling technologies, (2) identifying and representing data imperfections and lineage, (3) modeling object data acquisition and management, (4) addressing moving objects – map merging and tracking, (5) understanding what data needs to be observed or collected, and (6) mapping observables to parameter needs of selected models.

3.2.3 Unstructured Information

3.2.3.1 Open Source information

OSINT is based on publicly available information as well as other unclassified information that has limited public distribution or access. Examples of OSINT include on-line official and draft documents, published and unpublished reference materiel, academic research, databases, commercial and noncommercial websites, "chat rooms," and web logs ("blogs").

3.2.3.2 OpenSource.gov

One source of consolidated OSINT is OpenSource.gov which provides timely and tailored translations, reporting and analysis on foreign policy and national security issues from the OpenSourceCenter and its partners. Featured are reports and translations from thousands of publications, television and radio stations, and Internet sources around the world. Also among the site's holdings are a foreign video archive and fee-based commercial databases for which OSC has negotiated licenses. OSC's reach extends from hard-to-find local publications and video to some of the most renowned thinkers on national security issues inside and outside the US Government. Accounts are available to US Government employees and contractors.

3.2.3.3 Metadata Extraction and Tagging Service (METS)

The Metadata Extraction and Tagging Service (METS) is a Department of Defense Intelligence Information System (DoDIIS) Core Service that extracts information found within unstructured documents. This promotes integration with structured data and will significantly improve search, analysis, and knowledge discovery. METS automates the normalization of, and extraction of information from, text documents, making the content of the documents quickly available as XML and OWL (Web Ontology Language) / RDF (Resource Description Framework) for intelligence analysis.

GML in METS is a conversion of a very small piece of the GML XML spec. It lumps together some small ontologies recommended by the W3C. It was supplemented by a few additional GML concepts used by DoD Discovery Metadata Specification (DDMS).

3.2.4 Information Integration

3.2.4.1 Linking

In order to connect the dots, information elements must be linked which many times depends upon the information being tagged with attributes describing its semantics. OGC discussion have focused on the need to increase the use of linking standards such as xlink and 'URIReference'. [Cox, 2010]

OGC has developed draft proposed standards for linking unstructured information with geographic tags:

- Geolinked Data Access Service
- Table Joining Service (TJS)

3.2.4.2 Tagging

Tagging of data from structured and unstructured sources is valuable towards integration of

- UCore
- Department of Defense Discovery Metadata (DDMS)
- Dublin Core

Tagging is done differently for hard versus soft sources. In hard fusion from a known sensor, tagging is often object attribution and feature characterization. While soft fusion must deal with increased uncertainty and provide basic context, e.g., location for hand-held photos, semantic labels for correlation, etc.

3.2.4.3 Ontology Alignment

Current conceptual models for information fusion, including the JDL model do not consider the fact that their information sources are often based on different ontological bases. [Dorion, 2007] therefore suggests that the JDL model, which caters for space and time common referencing, be augmented with the notional aspect of common ontological alignment. Ontology alignment is the act of establishing a relation of correspondence between two or more symbols from distinct ontologies, for those symbols that denote concepts that are semantically identical, or similar.

Standards directly relevant to decision fusion for ontologies include:

- OWL
- RDF

3.2.4.4 Advanced Authoring Format (AAF)

Understanding a timeline events can be critical to Situation Awareness. Advanced Authoring Format (AAF) can be used to place various information elements into a timeline. AAF was developed for the interchange of audio-visual material and associated metadata. While the original purpose of AAF is for video post production and authoring environment, AAF has been applied to fusion of multiple information sources regarding an actual timeline. [AMWA, 2010]

3.2.4.5 Uncertainty

Uncertainty propagation was a theme across all of the fusion categories discussed in the Phase 1 of Fusion Standards Study. Methods for propagating uncertainty into a decision framework are needed. Methods for presenting uncertain information in human-machine interface are needed. Communicating uncertain information to users is a non-trivial task and must build upon the results of on-going research. Development of this topic should begin with a “hard fusion” topic, i.e., a topic for which the uncertainty can be calculated from input uncertainty values.

- Uncertainty Markup Language (UnCertML) – OGC Discussion Paper

3.3 Services for Decision Fusion

3.3.1 Service-Oriented Architecture

The most effective environment for accomplishing the various types of fusion is expected to be a network-centric architecture with distributed databases and services based on a common core of standards-based data formats, algorithms, services, and applications. Such an environment allows the various forms of information to be collected, stored, managed, fused and disseminated vertically (from international to individual level) and horizontally (peer to peer).

A fusion environment involves people, processes, data, and technology that combine functional information with information about space and time (Figure 6). 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 and to provide a common situational understanding and a cohesive set of decision solutions.

In the conceptual fusion environment depicted in Figure 6, 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. Interoperability Nodes and External Source Nodes may support a variety of service and encoding standards, supporting both producer and consumer interconnections.

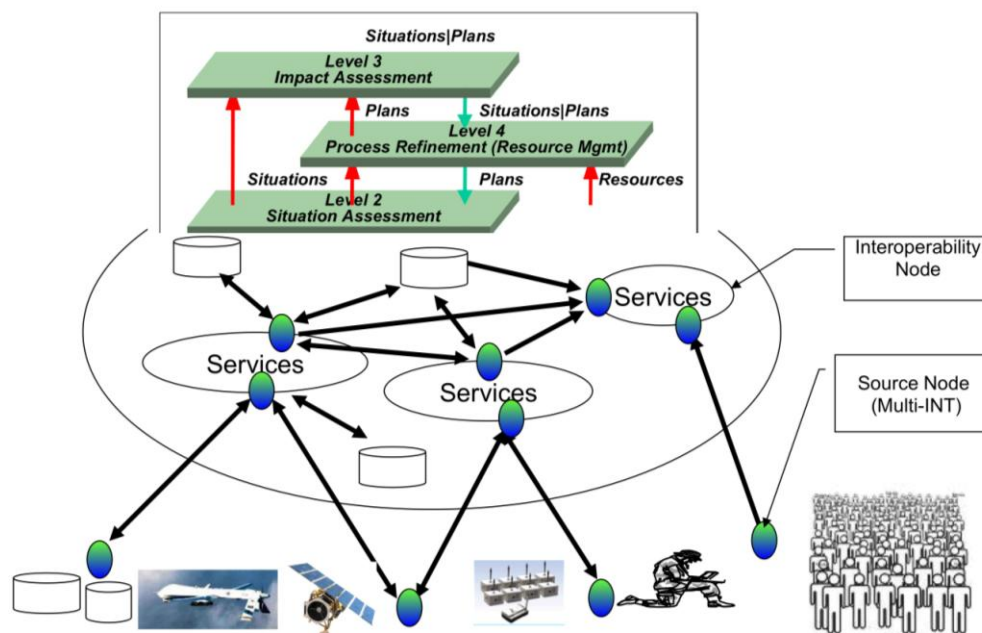


Figure 6 – Fusion Services Environment

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.

The example architecture shown in Figure 7 enables the fusion of geospatial data among sensors, image libraries, geospatial products, and other intelligence data sources [NGC, 2009]. In the figure, the Enterprise Services level include Sensor and Feature fusion processing in the Processing Services. These processing services for fusion include feature conflation and image enhancement that use multiple sources from the information and data management level, brokered through standard information exchange mechanisms. Discovery of fusion sources; schema and business rules for conflation would be provided through the Discovery services. Decision level fusion is provided through Information Management services and Integrated Clients as part of the Enterprise Applications. Workflows at the Enterprise Management level provide the logical flow and chaining to run services together in application of fusion for clients, whether a person using a client interface or another web service.

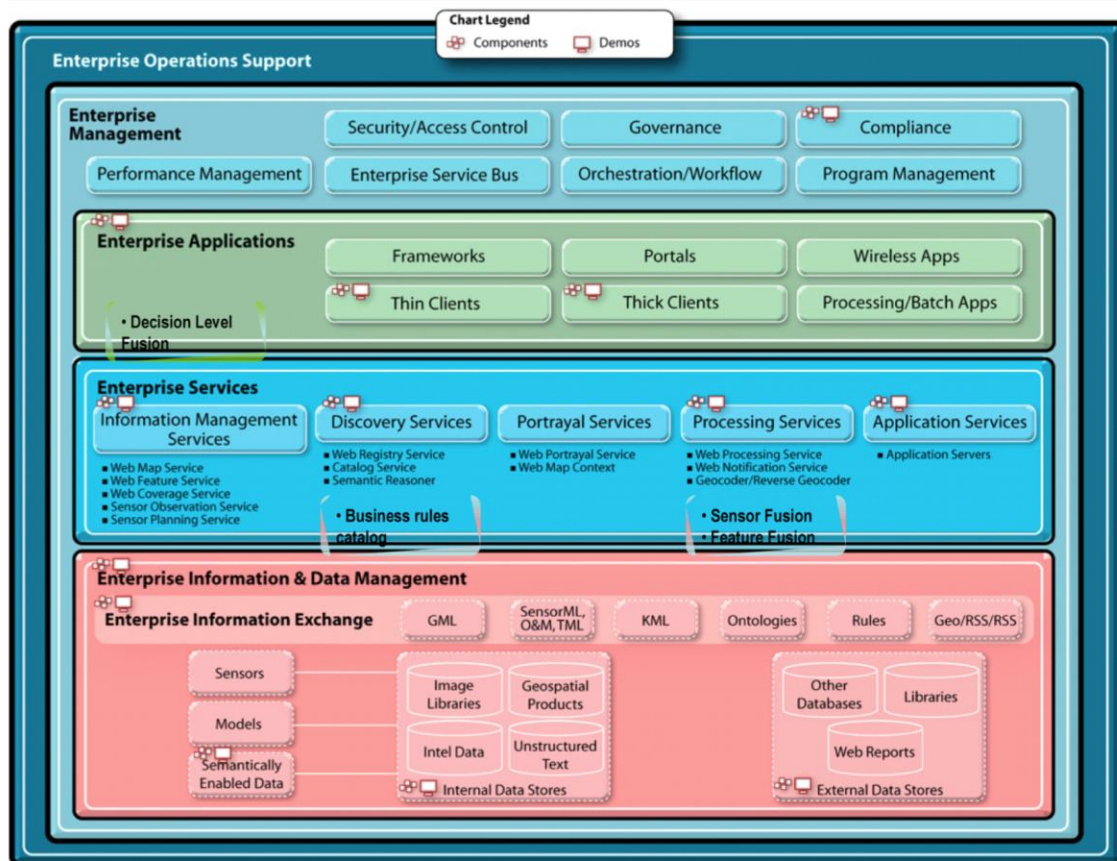


Figure 7 – Example Fusion Architecture [NGC, 2009]

3.3.2 Service Platforms

Services may be deployed using multiple technologies, e.g., REST, SOAP, JAVA. The OGC recommends development of service oriented architecture standards using platform-independent abstract specifications and platform-dependent implementation specifications for all OGC service standards that support both procedure-oriented and resource-oriented service styles or patterns.

3.3.3 Services

The section identifies standards relevant to the services and components identified in the service-oriented architecture of the previous section.

3.3.3.1 Messaging: Alerts and Events

Much exchange of messages in a fusion environment is done using e-mail. These messages relate to specific events and are also used for planning and requirements

Alerts are structured information intended for immediate human attention. Alerts maybe passed by e-mail and more specialized services defined for SOAP and REST environments.

Events are structured information but not necessarily intended for immediate human attention. Events maybe passed by e-mail and more specialized services defined for SOAP and REST environments. OGC has defined events services for sensor related services. [Everding, 2009]

In addition to direct exchange of messages from producer to consumer, the publish/subscribe pattern allows for looser coupling of the source and receiver of messages.

In the SOAP oriented, “WS-*” world, publish / subscribe can be handled with WS-Notification [OASIS, 2006]. WS-Notification makes use of notification topics, which support a mix of the subscription models channels and types.

Instant messaging approaches may be considered for message passing. XMPP is a standard for XML message streaming. Various commercial vendor solutions for instant messaging also exist.

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

3.3.3.2 Search including filters

Search has many variations: searching of a catalogue, federated search across multiple catalogues, real-time filtering of feeds.

The OGC Catalog Service Specification is an interface standard that can be used on any catalogue and includes geospatial extensions. The OGC Catalogue service can be applied to centralized or federated search architectures.

Harvesting of distributed information in advance allows for a user query to be evaluated against a single catalogue. As examples, two centralized catalogues are:

- The Catalyst program uses metadata to correlate information from diverse intelligence sources (multi-INT), without attempting to fuse all of the original intelligence directly. Catalyst will operate upon tagged entities such as person names and place names and expose this metadata to algorithms. [ODNI, 2008]
- Google crawls the Web to collect the contents of every accessible site. This data is broken down into an index (organized by word, just like the index of a textbook), a way of finding any page based on its content. Every time a user types a query, the index is

combed for relevant pages, returning a list that commonly numbers in the hundreds of thousands, or millions. The trickiest part, though, is the ranking process — determining which of those pages belong at the top of the list. [Levy, 2010]

Federated search is the process of performing a simultaneous real-time search of multiple diverse and distributed sources from a single search page, with the federated search engine acting as intermediary. Important Features of Federated Search: aggregation, ranking, and de-duplication (or “dedup’ing”).

As resources become more dynamic new methods for search are needed. This is in particular true for web resources such as news feeds, blogs, and social media. Typical catalogues first aggregate content via time-consuming harvesting. These factors have increased the demand for an opportunity for real-time search using filters. [Geer, 2010]

3.3.3.3 Data access: structured and unstructured

Access services to unstructured, open-source data focus on the WWW – http and associated protocols.

Structured data access services may include additional semantics related to the data structure. For example access to geospatial data can be accomplished with these open standards:

- OGC Web Map Service
- OGC Web Feature Service
- OGC Web Coverage Service

3.3.3.4 Social Networking

Data Fusion needs access to tools such as Social Networking Services (SNS), social media, user-generated content, social software, e-mail, instant messaging, and discussion forums (e.g. YouTube, Facebook, MySpace, Twitter, Google Apps).

Social networking can be used on trusted networks perhaps within a decision node or set of coordinate nodes, e.g., A-space. Social networking using public is relevant to the mission of decision fusion, where the sources may not be trusted.

Social networking are becoming recognized as integral to operations in many domains, e.g., US Department of Defense [DoD, 2010].

Examples of Social networking relevant to Decision Fusion, several need to be enhanced with geospatial capabilities:

- A-Space is a common collaborative workspace for US intelligence community analysts. A-Space, will give analysts shared access to corporate data and to numerous databases maintained by individual IC organizations. [ODNI, 2008]
- Intellipedia is the US Intelligence Community’s (IC) version of the world’s user-annotated online encyclopedia, Wikipedia. Intellipedia enables collaborative drafting of short articles, which can be combined to form lengthy documents, all using a simple interface in a web browser. [ODNI, 2008]
- GeoChat aims to integrate mobile field communications with situational awareness. Geochat - a google.org supported project for responding to disease spread and disasters GeoChat emerged from a simple concept - can I send an SMS message and see it on a map? InSTEDD GeoChat is a unified mobile communications service. [InSTEDD, 2010]

Of particular importance for social networking is the need to identify methods for capturing and retaining provenance of the source.

3.3.3.5 Visualization and Portrayal

A key aspect for establishing context is the visualization of an environment. Visualization for decision fusion in a network environment can be accomplished in two, three, or more dimensions, for example including temporal or parametric content, or links to relational data tables.

The OGC Web Map Service (WMS) standard allows fusion of two-dimensional images to be fused based upon common coordinate reference system.

The OGC Web 3-D Services (W3DS) discussion paper allows fusion of three-dimensional models to be fused based upon common coordinate reference system: scene composition.

Visualization must include the ability to change the Symbology for features displayed. Symbology styles may be used to provide still more hints to an analyst or other user. Data and map product specifications generally determine the precise symbology to be used in a given context. But additional conventions may be suggested and prototyped for distinguishing selected features and/or feature properties from their neighbors and surrounding background. As information sources become ever more cluttered with detail, it becomes increasingly important to find ways to focus attention where it is most needed.

The OGC SLD Profile for WMS standard defines an encoding that extends the WMS standard to allow user-defined symbolization and coloring of geographic feature and coverage data. SLD addresses the need for users and software to be able to control the visual portrayal of the geospatial data. The ability to define styling rules requires a styling language that the client and server can both understand. The OGC Symbology Encoding Standard (SE) provides this language.

Of particular interest for urban situations is viewing 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. 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.

3.3.3.6 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.

- OWS Context standard
- KML standard

For decision making in a collaborative environment, communications mechanisms and services are needed. As demonstrated in OWS-3, a video feed from a UAV over a fire location is broadcast to several locations.[OGC, 2005] The several locations are connected so that they can see the same video, with the ability for each location to highlight a location on the video for the other locations to see. While sharing and co-interacting this common picture the locations are able to talk and chat. The result being artifacts to be saved and made part of the decision object. This coordination can be achieved with OWS Context, KML, LoF, and other mechanisms. This

would require that OWS Context be extended to support imagery, video, audio, digital data, map represented data – for multi-int fusion.

3.3.3.7 Sensor webs

Decision nodes need access to sensor fusion results and the ability to request additional sensor information. Access to sensors using standards is accomplished with the OGC Sensor Web Enablement (SWE) standards:

- Sensor Observation Service
- Sensor Planning Service
- Sensor Alert Service

3.3.3.8 Processing and Analysis

In order to support decision fusion, in some cases processing of the source data is required.

Use of the OGC Web Processing Service (WPS) with profiles enables a standards based approach to many types of analysis.

Processing to provide thematic, statistical, exploratory, spatial/topological and other forms of analysis with open access (public, non-standard) and multi-media data of a socio-cultural nature is a topic in the OWS-7 Testbed using WPS. This is of primary importance to anticipate, prepare for, and mitigate situations requiring urgent and emergency response. In OWS-7 Testbed this type of analysis is referred to simply as *Feature and Statistical Analysis (FSA)*, which we define as a *multidisciplinary scientific approach to describe and predict spatial and temporal patterns of human behavior by analyzing the attributes, actions, reactions and interactions of groups or individuals in the context of their environment*. FSA incorporates elements of Human Geography in a spatial, temporal context. FSA includes aspects of Socio-Cultural Dynamics (SCD), which is defined as information about the social, cultural and behavioral factors characterizing the relationships and activities of the population of a specific region. FSA also includes geospatial vector and topology processing operations.

3.3.3.9 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 using such standards as BPEL. 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 is 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. [Schäffer, 2009]

To cope with the crush of huge and growing data volumes to be processed, it is important to augment human awareness and expert knowledge with service-supported workflow processes as much as possible. This could be in the form of enhanced context awareness governing choices available and properties of each choice in a workflow. A key objective is to improve the quality of any given workflow, while lowering its cost, and improving performance. Tradeoffs of regarding roles of human in the loop vs. full automation of workflow should be investigated.

3.3.3.10 Security

The architecture must apply standards-based security solutions for deploying services in the fusion domain. This brings in the requirement for handling services that sensors and other data sources that produce classified information and the main objective of accreditation.

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

RFI responses should respond with requirements and solutions for approaches to security, e.g., authentication and authorization, based on existing products. RFI is seeking to identify major drivers related to fusion anticipating that much of the existing certification applies directly to the deployed solutions.

3.3.4 Fusion Analyst Components

3.3.4.1 Decision analysts toolbox

In order to access the services and to exchange information, a Decision analyst needs to be provisioned with a set of tools including desktop clients and access to distributed/cloud services.

The Global Justice program identifies a set of tools as the basic toolbox that an intelligence analyst will need. In addition to the basic office applications on a personal computer, the toolbox should allow access to this information locally or remotely [Global Justice, 2006]:

- Mapping/Geographic Information System (GIS)
- Public Information Database Resources
- Statistical Analysis Software
- Timeline/Flowcharting
- Link Analysis
- Investigative Case Management
- Communications/Telephone (Toll) Record Software

An option presented to NGA based on a previous study was an "Analyst Fly-away kit" as a pre-configured analyst environment containing information (e.g. open source information, RSS feeds, etc.) that would support the analysis process. This would enable experienced analysts to develop "lessons learned" from deployments (i.e., "if only I had known this information, or included this tool...") to help other analysts. [InnoVision, 2009]

3.3.4.2 Integrated client

Decision fusion application components access remote data from one or more Web services and provide manipulation of the data in the client application. Decision support functionality may include filtering, aggregation, analysis, visualization, presentation, and interpretation of multiple sources of data. Decision support clients may be specific to a user community or may be more generic geospatial data applications. Client applications which can be distributed free of charge are desired, note that this does not necessarily require that the code be open source.

While this type of application is generally understood to be a user-facing component, this does not restrict the computing platform by which it is implemented. The application may be implemented in software running "standalone" on the user's desktop, or it may be generated by software running on a remote server and "delivered" through a Web browser.

3.3.4.3 Fusion Portal

A Web portal is a single point of access to information, which is linked from various logically related Internet based applications and is of interest to various types of users. Development of reusable portlets increases reuse between portals.

Portals present information from diverse sources in a unified way; they provide a consistent look and feel with access control and procedures for multiple applications, which otherwise would have been different entities altogether. Generally, a portal provides:

- Intelligent integration and access to enterprise content, applications and processes
- Improved communication and collaboration among customers, partners, and employees
- Unified, real-time access to information held in disparate systems
- Personalized user interactions
- Rapid, easy modification and maintenance of the website presentation

3.3.4.3.1 *Decision 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 8. A Decision Fusion Engine is conceived as a component that has access to streams of information relevant to an operational decision setting. The fusion platform would create visualizations, and support analysis of aggregated data. Temporal analysis should also be supported by animation and filtering. Any of these analyses or visualization can be shared as embeddable objects into a variety of Web based collaboration software (wiki’s, blogs, web pages etc.).

As an example, the FortiusOne GeoIQ platform allows results of any analysis or data aggregation to be visualized including dynamic aggregation and disaggregation of data. Data can be also visualized through its temporal dimensions by animation and filtering. Any of these analyses or visualization can be shared as embeddable objects into a variety of Web based collaboration software (wiki’s, blogs, web pages etc.).” [FortiusOne, 2009]

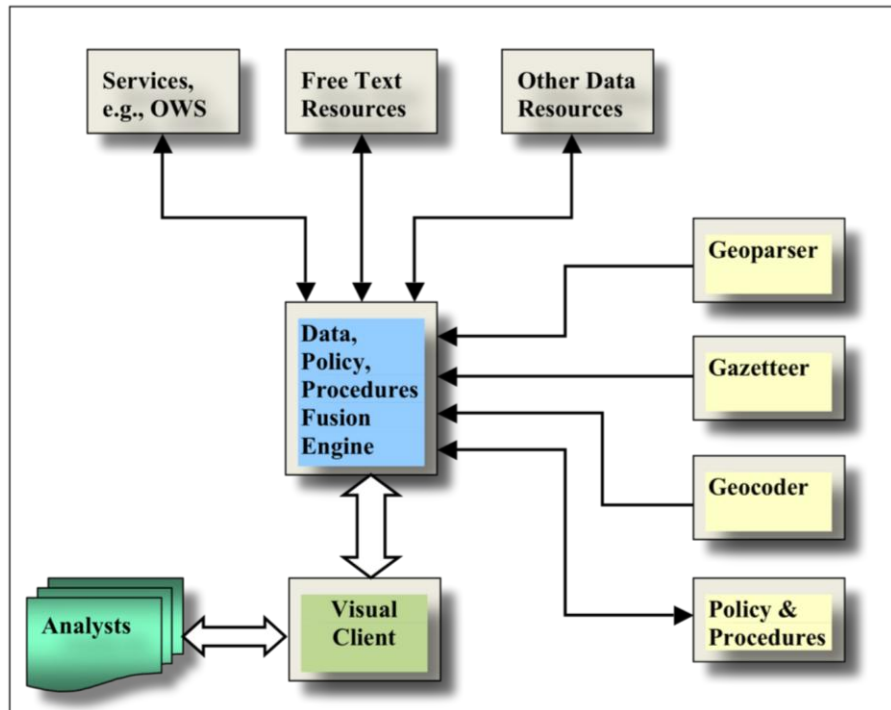


Figure 8 – Geospatial Fusion Services Engine Environment

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 and models of Decision Fusion
 - 3.2 Information for Decision Fusion
 - 3.3 Services for Decision Fusion
3. Organization description

The content of the “Elaboration” section should describe decision 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 existing standards and where new standards might be needed.

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 in a separate document that is clearly marked as containing proprietary information.

4.4 Questions and Clarifications

An RFI Clarification Conference Call will be scheduled and announced on the OGC web page for this RFI: <http://www.opengeospatial.org/standards/requests/67>

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	21 April 2010
RFI Clarification Conference Call	See OGC website for date: http://www.opengeospatial.org/standards/requests/67
Clarifications Posted	Initial posting: 1 day after receiving questions Final posting: 4 June 2010
RFI Responses Due	11 June 2010 – 5:00 pm EDT

4.7 Postscript

Much has been written and accomplished in the area of fusion. The focus of this study phase is on standards for decision fusion. RFI responses are encouraged to be terse.

Paraphrasing William James: "Wisdom is knowing what to leave out."

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