Standards Based Fusion: Driving Interoperability for Improved Situational Awareness and Decision Making

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OGC’s Fundamental Goal -- Interoperability

• You know when you don’t have it:
  – Custom Integration
  – High lifecycle costs
  – Difficult to rapidly mobilize new capabilities
  – Duplication of effort
  – Missed opportunities for improved decision making
Rapid discovery, access, fusion and application of location information for:

- Critical Infrastructure
- Emergency Management
- Weather Forecasting / Warning
- Climate Change
- Defense and Intelligence
- Local Government Services
- Routing / Logistics
- And many more applications…
The Common Operational Picture

Core OGC Web Services Standards:

- Web Map Service (WMS)
- Web Feature Service (WFS)
- Web Coverage Service (WCS)
- Catalogue (CSW)
- Geography Markup Language (GML)
- KML
- Others…
Rapidly Discover, Access, Task, Fuse and Apply Sensor Assets

Constellations of heterogeneous sensors

- Satellite
- Airborne
- Weather
- Surveillance
- Chemical Detectors
- Biological Detectors
- Sea State

Vast set of users and applications

Network Services

Sensor Web Enablement

Enterprise Services

OGC Sensor Web Enablement Standards

- Discover sensors and sensor networks
- Access sensor observations
- Apply in location and time context
- Task sensors
- Receive alerts and notifications
- Rapidly mobilize new / additional sensor assets

OGC Standards:

- SensorML
- Observations & Measurements
- Sensor Planning Service
- Sensor Alert Service
- Sensor Observation Service
- Transducer Markup Language
- Catalogue

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Ocean Observation

Earth Observation / Satellite Operations
NASA, ESA
Open Standards-based Sensor Architecture

User Domain
- User Interface Support

Application Domain
- Visualisation
- Reporting
- Sensor Applications e.g. DSS

Mediation & Processing Domain
- Processing Services (e.g. fusion)
- Model Management

Acquisition Domain
- Sensor Services

Sensor Domain
- Intermediate Sensor Services

http://www.sany-ip.eu/
Open Standards-based Sensor Architecture
3D Urban Models – OGC CityGML

• Urban Planning
• Emergency Mgt / Response
• Transportation / Logistics
• Retail Site analysis
• Sustainable / Green Communities
• City Services Management
• Noise abatement
• Many other uses…

Source: Thomas Kolbe. TU Berlin

Source: GTA Geoinformatik GmbH
Communication over the web using HTTP

OGC Web Processing Service

WPS-client

GetCapabilities
DescribeProcess
Execute

Algorithms Repository
Data Handler Repository

Algorithm 1
Data Handler A

Web Processing Service
Standards-based Multi-source Fusion for Actionable Situational Awareness

Web based integration of geospatial data from multiple distributed sources

Discovery, tasking, access and integration of sensor feeds - fixed and mobile sensors

Standards-based Decision Support Services available to support Actionable Situational Awareness

Fusion of Building Information Models and other engineered information

OGC Web Services Phase 4 Testbed (2006)

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Approved OGC Implementation Standards
Freely available at www.opengeospatial.org

- **Catalogue Services**
  - Catalogue Service

- **Processing Services**
  - Open Location Services (OpenLS)
  - Coordinate Transformation Service
  - Sensor Planning Service (SPS)
  - Web Processing Service (WPS)

- **Portrayal Services**
  - Web Map Service

- **Data Services**
  - Grid Coverage Service
  - Simple Features (4)
  - Web Coverage Service
  - Web Feature Service

- **Encodings**
  - Geography Markup Language (GML)
  - Styled Layer Descriptor (SLD)
  - Transducer Markup Language (TML)
  - Sensor Model Language (SensorML)
  - CityGML
  - Web Map Context (WMC)
  - Observations & Measurements (O&M)
  - Filter Encoding
  - KML
  - Symbology Encoding
  - GML in JPEG 2000
  - Geographic Objects
  - GeoXACML

- **Web Services Common**

- **Open Location Services**
OGC Alliance Partnerships
A Critical Resource for Advancing Standards

... and others

www.opengeospatial.org/ogc/alliancepartners

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A Current Focus Area:

Standards-based Fusion for Improved Decision Making
Fusion Standards Study

• OGC Fusion Standards Study, Phase 1
  – Sponsored by NGA Innovision
  – Request for Information (RFI) Issued Summer 2009
  – Results / Recommendations produced in time to influence OGC Web Services Phase 7 Testbed (now underway)

• Decision Fusion Standards Study, Phase 2 Underway
  – Focuses on Decision Fusion (Multi-INT)
  – Request For Information issued, responses due by 11 June 2010
Fusion Standards Study - Scope

• Working definition of Fusion:

  “Process of combining data and information to improve detection, identification, and characterization of entities”

• Categories of Fusion
  – Sensor Fusion
  – Object/Feature Fusion
  – Decision Fusion

• “To-Be” fusion environment based on open standards
Sensor Fusion

- **Sensor Observations**
  - Provide sensor measurements for fusion processing
  - Discover and task assets for additional information

- **Objects**
  - Provide recognized objects for use in fusion rule sets
  - Identify objects through fusion of observations and/or objects

- **Fusion Processes**
  - Fusion processes might involve strictly sensor observations, strictly objects, or a combination of observations and objects

- **Alerts, reports, and archive**
  - Identify objects using geometries and signatures
  - Provide recognized objects for use in fusion rule sets
  - Identify objects through fusion of observations and/or objects
Sensor Fusion Recommendations

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

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

OGC:  Web Feature Service
      Web Processing Service
W3C:  SOAP, WSDL
OASIS: BPEL
Decision Fusion Recommendations

- Develop an information model with decisions as a first class object
- Define interfaces and functionality for decision fusion engine component type
- Uncertainty propagation for a “hard fusion” topic
- “See and Talk” collaboration with common view
- Coordination through social networks
- Political Geography as a step to all information types
- Dynamic routing based on location
- Issue separate study focused on decision fusion
• Use of Open, Community IT Standards

• Semantics mediation of community vocabularies, taxonomies

• Workflow driven by semantics

• Grid and Cloud implementations for performance and access
Fusion Standards Study Public Engineering Report
Available www.opengeospatial.org/standards/per

Contents
– Fusion Standards Study Overview
– Definition and Categories of Fusion
– Summary of Recommendations
  • Sensor Fusion
  • Object/Feature Fusion
  • Decision Fusion
  • Architecture for Fusion

OGC® Fusion Standards Study Engineering Report

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• Development of a use case based evaluation of integrating data and information from multiple intelligence sources.
  – MLS
  – Info exchange between analysts and in-the-field forces,
  – metadata tagging to include life-cycle from collection to update to fusion
  – Defense and HLS context
• Focus on standards
  – Review of existing standards regarding fusion;
  – Survey of standards and implementations with the focus on multi-INT information sources.
• Consider Mass Market and Mashup Technologies
• RFI available, responses due 11 June 2010
OGC Web Services Initiative, Phase 7 (OWS-7) Summary

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OGC Interoperability Program
OWS-7 Initiative Lead
OWS-7 Testbed Threads

- Sensor Fusion Enablement
- Feature & Decision Fusion
- Aviation

OWS-7

- Sensor Web Enablement
- Geospatial Processing Workflow
- Decision Support Services
- Aviation

OWS-6

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**OWS-7 Themes & Threads**

• Themes
  - SFE (Sensor Fusion Enablement)
    • Sensor tracking - *Motion video change detection*
    • CCSI toxic sensor interfaces
  - FDF (Feature and Decision Fusion)
    • *Data discovery, management and analysis of geo and non-standard information*
    • Information sharing - *GML schema automation*
    • Feature & statistical analysis - *Geosynchronization*
  - Aviation
    • Airfield Information XML - *Notifications*
    • Dispatch & flight operations - *Weather Information Exchange Model (WXXM)*

• Cross-cutting Themes
  - Event architecture, alerts, and notifications
  - Web Processing Services (WPS) best practices for profiling
  - Catalogue for all data sources, sensors, and application schemas
OWS-7 Testbed Statistics

• Schedule
  – Call for Sponsors: June 2009
  – RFQ/CFP issued: October 2009
  – Kickoff: January 2010
  – Demonstrations: June 2010

• Deliverables
  – 39 Components
  – 15 Engineering Reports and Change Requests
• Haiti Earthquake Disaster
  – Rapid discovery and analysis of cultural and demographic data, in combination with base map and damage information, to determine neighborhoods needing priority help
  – Using CCSI sensors to detect radiological leaks around damaged hospital
  – Geosynchronization of database updates

• Search for IEDs in Urban Environment
  – Sensor tracking and video capture for change detection, in search of Improvised Explosive Devices (IEDs)
  – WPS for change detection in video feed, triggering alerts

• Aviation Response to Weather
  – Preflight diversion planning and airport status notification
  – Volcanic eruption and resulting diversions due to ash plume
OWS-7 Sponsors

- U.S. National Geospatial Intelligence Agency (NGA)
- U.S. Federal Aviation Administration (FAA)
- EUROCONTROL - The European Organization for the Safety of Air Navigation
- U.S. Army Geospatial Center (AGC)
- U.S. Geological Survey (USGS)
- U.S. National Aeronautics and Space Administration (NASA)
- EADS Defence and Communications Systems (DCS)
- BAE Systems
- PCI Geomatics, Inc.
- Lockheed Martin Corporation
## OWS-7 Participants

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Sensor Web Enablement in OGC Testbeds
Standardization of Chemical, Biological, Radiological, Nuclear (CBRN) Sensors

From OGC Web Services Testbed Phases 6 and 7
Aeronautical Information Management (AIM)  
(OGC Web Services Phase 6 Testbed)

• Develop and test standards-based service-oriented architecture to support the provision of aeronautical information directly to flight decks and Electronic Flight Bags (EFB)

• Support vision for Aeronautical Information Management
  – Interconnected systems with many actors and many users
  – Need for real-time information used in flight planning, navigation, rerouting, etc
  – Right information at the right time at the right place to the right user
  – End-to-end management of information
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**NEW – NextGEN Network Enabled Weather**

**TAF – Terminal Aerodrome Forecast**

**WXXM – Weather Info. Exchange Model**

**WFS – OGC Web Feature Service**

**OWS-6 Aeronautical Information Management Architecture**

- **Aviation Clients**
  - EFB
  - PDA
  - Aeronautical Information User
  - Avionics Systems
  - Lufthansa Systems

- **Event Service**

- **U of Muenster**

- **Post Event**

- **Aeronautical Information Custodians**

- **Snowflake**

- **AIXM WFS**

- **Retrieve updates**
  - Retrieve full AIXM data filtered by time and location
  - Retrieve AIXM data for route of flight

- **Retrieve weather data**

- **NOAA**

- **Galdos**

  - AIM Engineering Report
    - Architecture
    - Scenario
    - Lessons Learned

- **Weather WFS**

- **WXXM TAF WFS**

- **Retrieve weather data**

**OGC**

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OGC Web Services Event Architecture

- OGC Sensor Web Enablement Event Architecture developed as part of OWS-6

- Discussion:
  - Event Definitions
  - Roles and Interfaces
  - Application Schema
  - Event Enabling OGC Based Architectures
  - Related Technologies

OGC® OWS-6 SWE Event Architecture Engineering Report

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www.opengis.org/standards/per
Debris Flow Monitoring - Taiwan

- Typhoons and earthquakes trigger landslides and flooding on a frequent basis.
- OGC services used with an array of spatial data and sensors to provide situational awareness for forecasting, detecting, alerting and response to debris flow situations.
- Rapidly deployed network of debris flow sensors, and distributed services performing sensor data analysis and processing.
A typical layout of a fixed monitoring station
Taiwan Debris Flow - OGC System Framework

- **SOS**
  - GIS.FCU, Taiwan
  - GetObservation
  - JSON

- **WMS, WFS-T**
  - GEOGrid, AIST, Japan
  - GSMaP Hourly image
  - GetFeatureInfo [Pixel value from start to end]
  - JSON

- **WPS**
  - Validation process
  - Least Square Fitting process

- **Sensor**
  - Rain gauge Observation System
  - Any Observation System

- **System Framework**
  - OGC
  - simplejson
  - rpy2
  - R
  - Etc..
Debris Flow Monitoring and Forecast Sensor GRID

SWE: Catalog Service for the web and associated metadata for SWE

Field survey
Mobile Observation

Services Catalog
Geo Phone
Rain gauge
Video cam
Water Level gauge
Wired sensor
Wavelet Transform
FF Transform
IDW interpolation

Sensor Network

Service Conflation
GPW: Service Conflation and Grid Processing

Debris flow Evaluation Workflow

WPS-Grid Processing

Is this event a debris flow?
Decision Maker
Geospatial Interoperability from sensing to decision support

OGC Web Services

Computer and Communication

Intelligence

Surveillance and Reconnaissance

Command and Control

SWE = Sensor Web Enablement
GPW = Geo-Processing Workflow
GDS = Geospatial Decision-support Services
Thank You

- OGC Technical Committee Meeting
  - Week of 14 June 2010
  - Hosted by NOAA, Silver Spring MD
  - Sensor Web Enablement Domain WG convenes Tuesday morning
  - www.opengeospatial.org/event/1006tcagenda
  - Contact mreichardt@myogc.org for more information
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- OWS-6 SWE Information Model Engineering Report