



# Implementation of Sensor Web Enablement

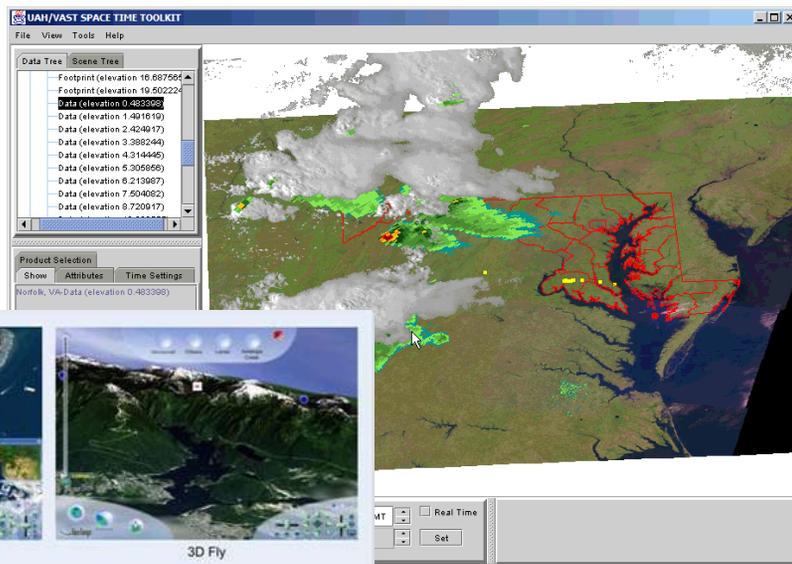
Presentation to SensorsGov, 7 December 2005  
Session: An Open Standards Infrastructure for  
Homeland Security for Sensor Network Interoperability

George Percivall

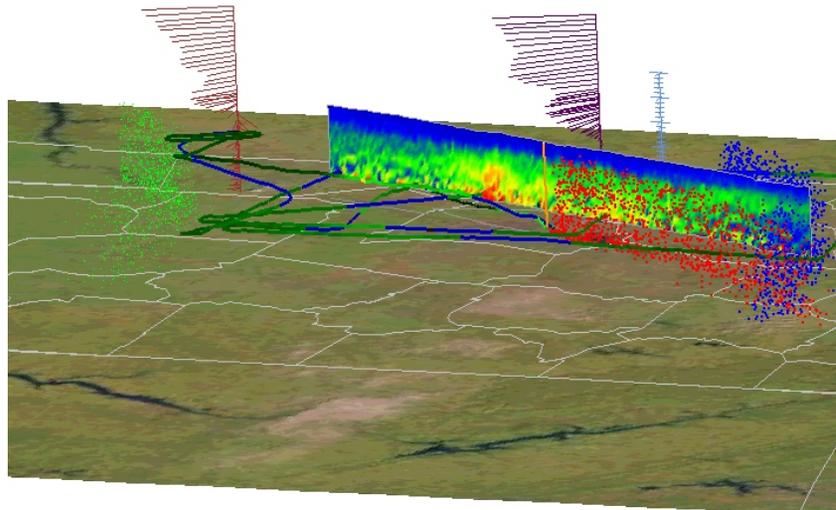
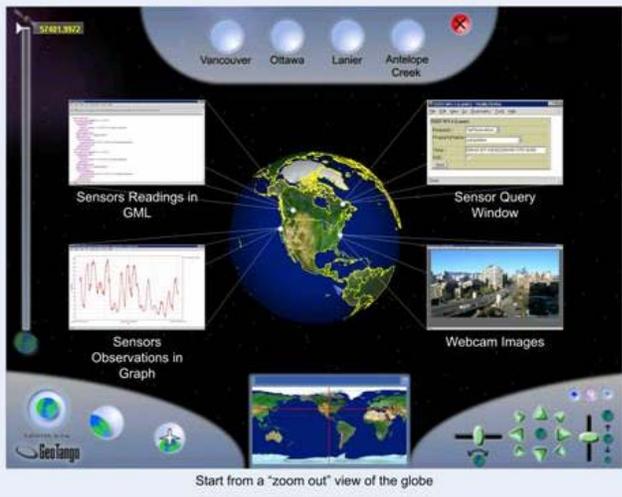
OGC Executive Director, Interoperability Architecture

[percivall@opengeospatial.org](mailto:percivall@opengeospatial.org)

# Integration Of Observations From A Variety Of Sensors



**Users desire the ability to discover and integrate observations from any sensor that meets their needs.**

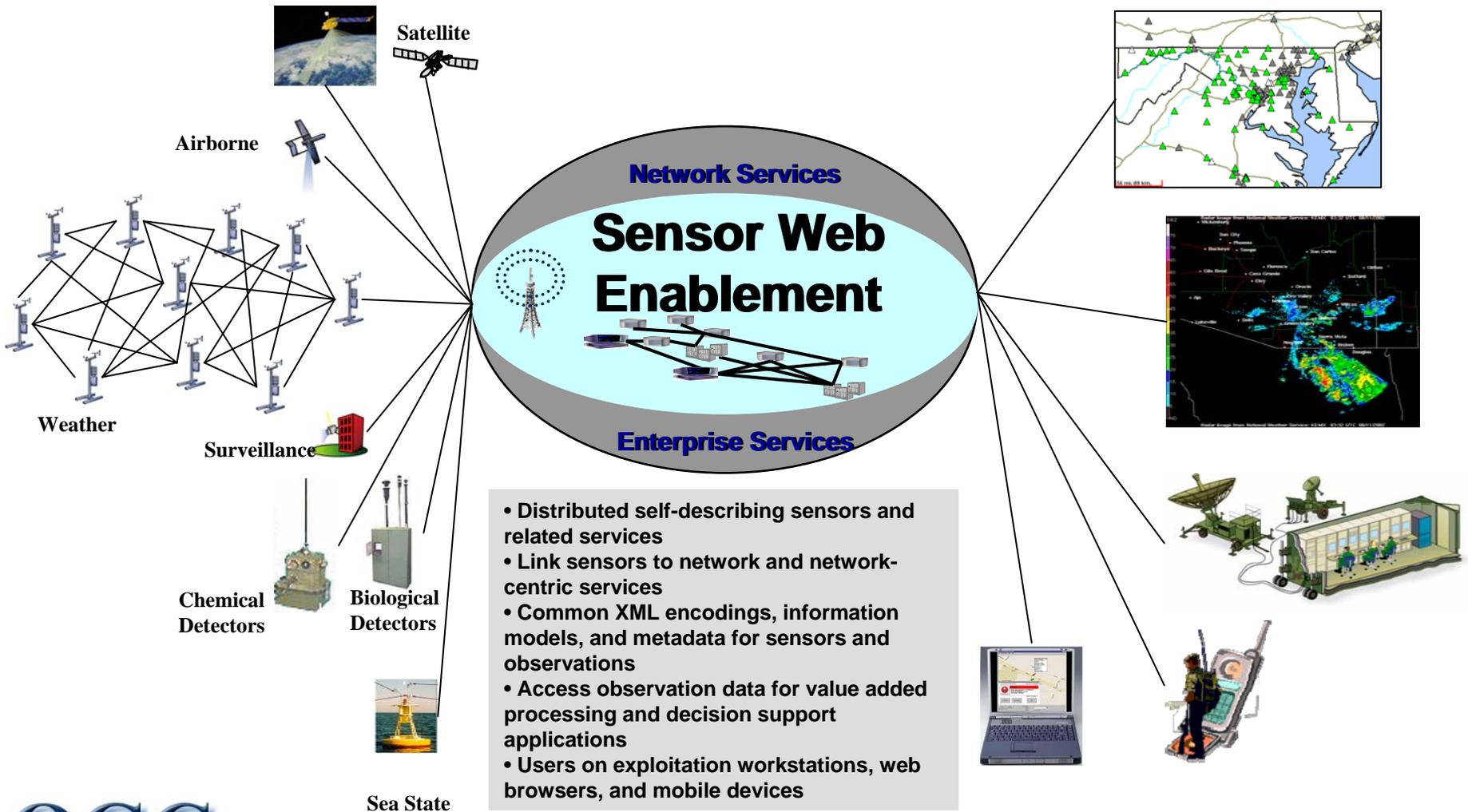


# SWE Operations Concept



Constellations of heterogeneous sensors

Vast set of users and applications



# What is OGC?



- **Open Geospatial Consortium (OGC)**

- Not-for-profit, international voluntary consensus standards organization
- Industry, government, and university members
- Founded in 1994, with 8 Charter members

## Mission

*To lead the global development, promotion and harmonization of open standards and architectures that enable the integration of geospatial data and services into user applications and advance the formation of related market opportunities.*

# OGC Today



- >300 members worldwide – 31 countries & 5 continents
  - 100 European members
  - 34 Asia-Pacific members
- 90+ Academic and Research Members
- 16 approved, publicly available Implementation Specifications fielded in hundreds of products
- 20+ candidate Implementation Specifications in work
- Significant interaction with ISO and many other standards organizations



**OGC**

*Helping the World to Communicate  
Geographically*

# Approved OpenGIS® Specifications



- Tightly coupled:
  - Simple Feature Access – OLE, SQL, CORBA
  - Grid Coverages 1.0
  - Coordinate Transformation 1.1
  - GO-1 Application Objects
- Focus on Web Services
  - Catalog 2.0
  - Web Map Service (WMS 1.3)
  - Web Feature Service (WFS 1.1)
  - Web Coverage Service (WCS 1.0)
  - Filter Encoding 1.0
  - Geography Markup Language 3.2 (GML)
  - Style Layer Descriptors 1.0
  - Web Map Context 1.0
  - OGC Web Services Common
  - Open Location Service Specification Set 1.0

Available free of charge at  
[www.opengeospatial.org](http://www.opengeospatial.org)  
(Documents)

The screenshot shows the OpenGIS® Specifications page on the OGC website. The page includes a navigation menu, a search box, and a table of specifications. The table lists the following specifications:

Type	Title	Version	Document #	Date	Description	Editor
IS	Catalog Interface (CAT)	1.1.1	02-08732	2002-12-13	Defines a common interface that enables diverse but conformant applications to perform discovery, browse and query operations against distributed and potentially heterogeneous catalog servers.	Doug Hebert
IS	Coordinate Transformation Services (CTS)	1.0	01-009	2001-01-12	Provides interface for general positioning, coordinate systems, and coordinate transformations.	Martin Daly
IS	Filter Encoding (Filter)	1.0	02-059	2001-05-01	A filter is a construct used to describe constraints on properties of a feature class for the purpose of identifying a subset of feature instances to be operated upon in some way.	Peter Vretanos
IS	Geography Markup Language (GML) (GML3.0)	3.0	02-0234	2003-01-29	The Geography Markup Language (GML) is an XML encoding for the transport and storage of	Simon Cox, Paul Hare, Ron Lake, ...

# OGC Impact on Geospatial Marketplace



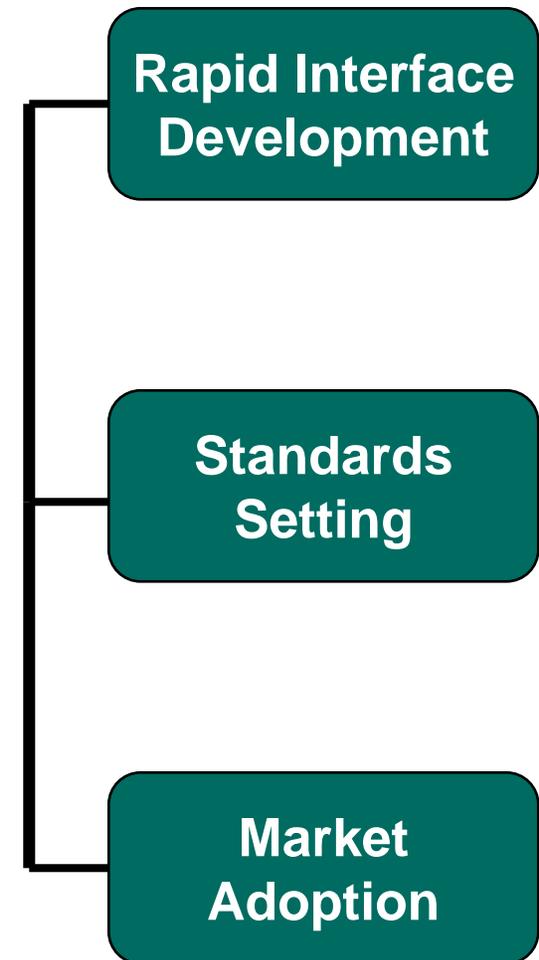
- Several hundred products are implementing OpenGIS Specifications
  - See OGC “[Registered Products](#)” List under “Resources” at [www.opengeospatial.org](http://www.opengeospatial.org)
- Formal Compliance certification is increasing in importance



# OGC's Approach for Advancing Interoperability



- **Interoperability Program (IP)**
  - Global, innovative, hands-on prototyping and testing program to accelerate interface development and validation, and bring interoperability to the market
- **Specification Development Program**
  - Consensus processes similar to other Industry consortia (World Wide Web Consortium, OMA, OMG, etc.).
- **Outreach and Community Adoption Program** – education and training, encourage take up of OGC specifications, business development, communications programs





# OGC Web Services, Phase 3 (OWS-3)

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- OWS-3 Testbed Objective
  - Work collaboratively to extend the OGC baseline to enable an interoperable, multi-source decision support environment
- OWS-3 Schedule
  - Call for Sponsors November 2004
  - RFQ February 2005
  - Develop and Testing 6 months
  - Demo and Reports October 2005
- Involvement
  - 12 Sponsoring organizations
  - 45 Participating organizations
  - 178 Individual participants

# OWS-3 Sponsors (12)

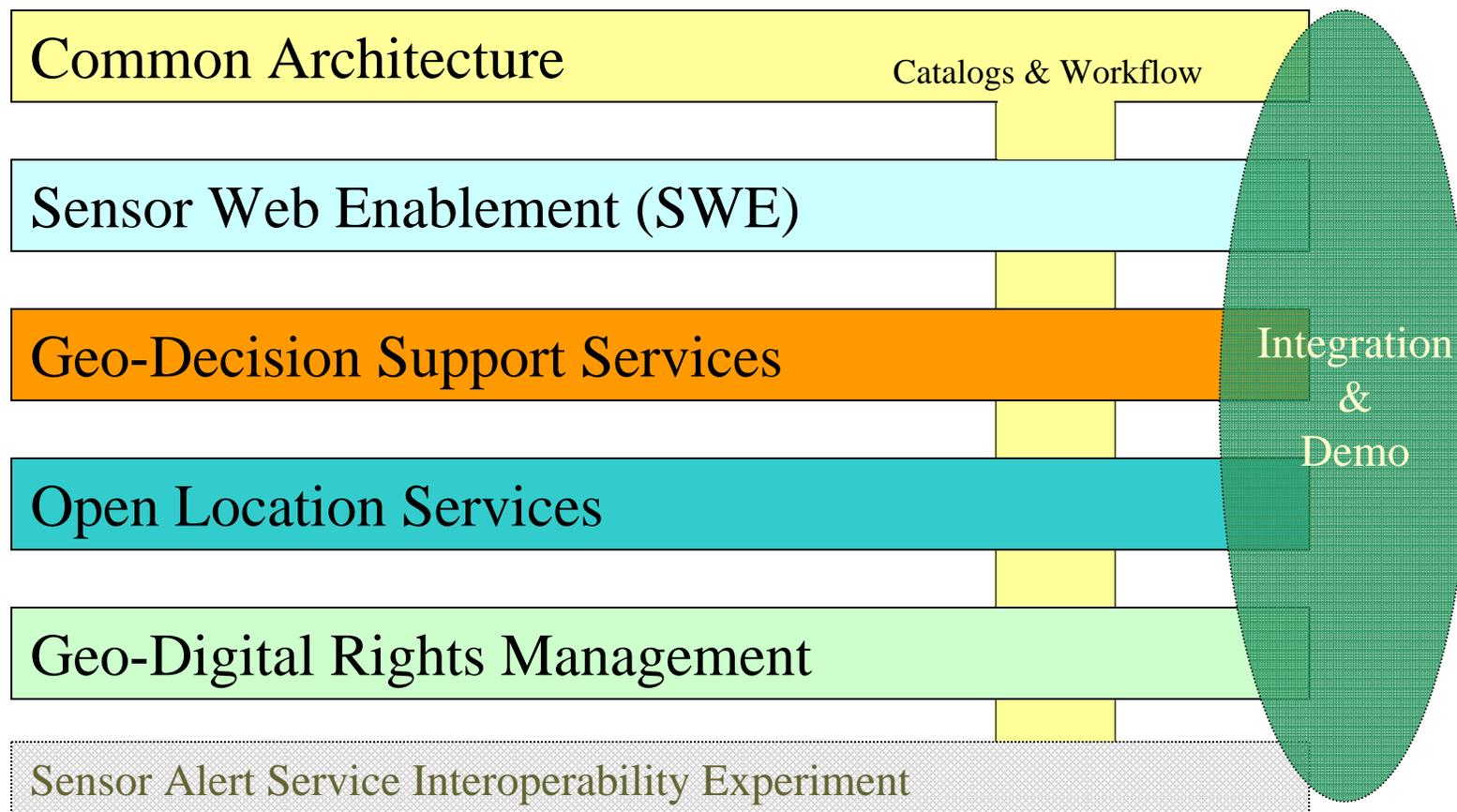
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- BAE Systems
  - GeoConnections (Canada)
  - Ionic Enterprise
  - Lockheed Martin
  - MAGIC Services Initiative
  - National Aeronautic and Space Administration (NASA)
  - National Technology Alliance (NTA)
  - NAVTEQ
  - Oak Ridge National Laboratory (ORNL)
  - Questerra
  - US Geological Survey (USGS)
- and other organizations.*



# OWS-3 Organization





# OWS-3 SWE

## Sensor Web Enablement

# Sensor Web Concept



**SWE Architecture**

**Observations & Measurements**

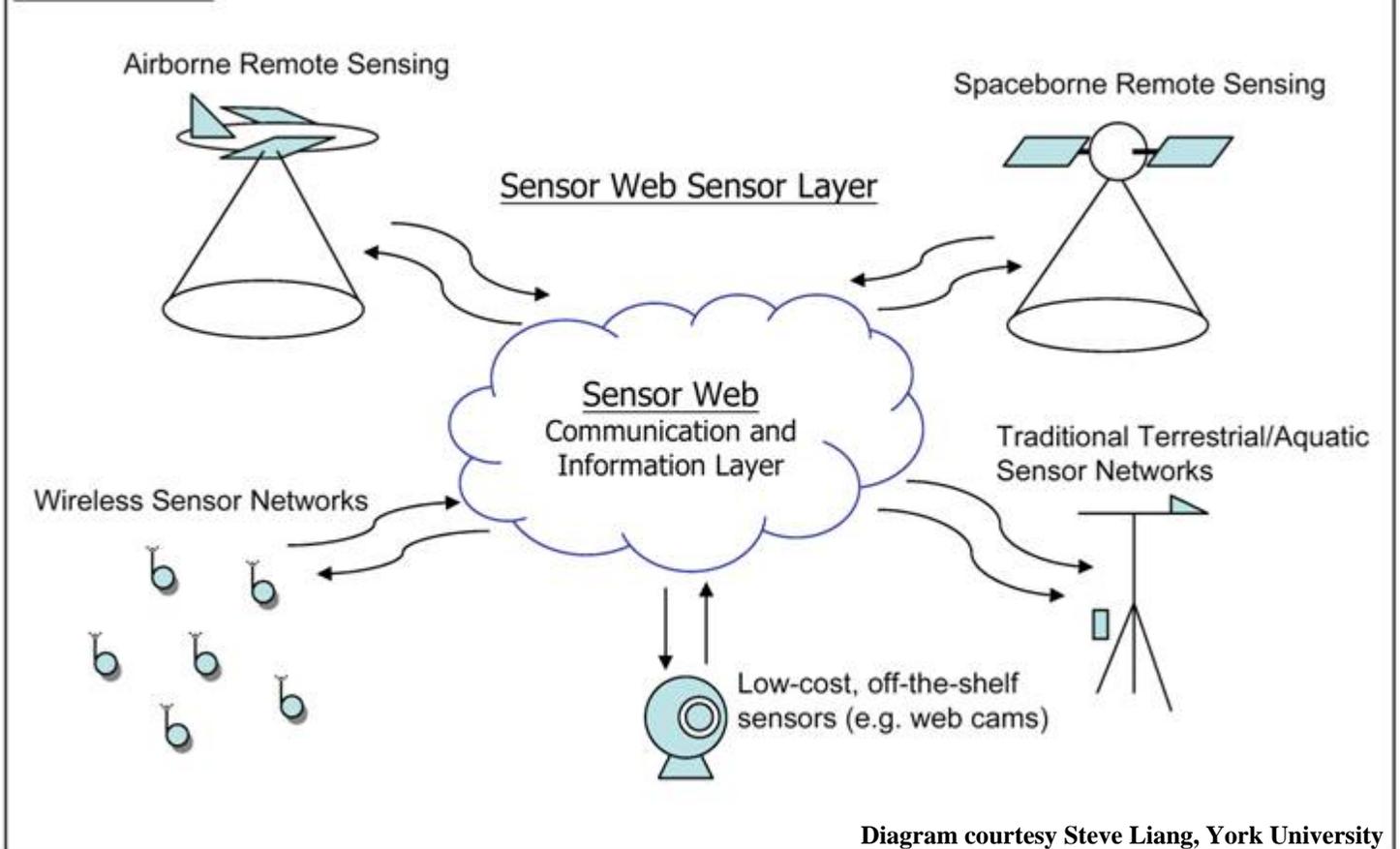
**SensorML**

**Transducer Markup Language (TML)**

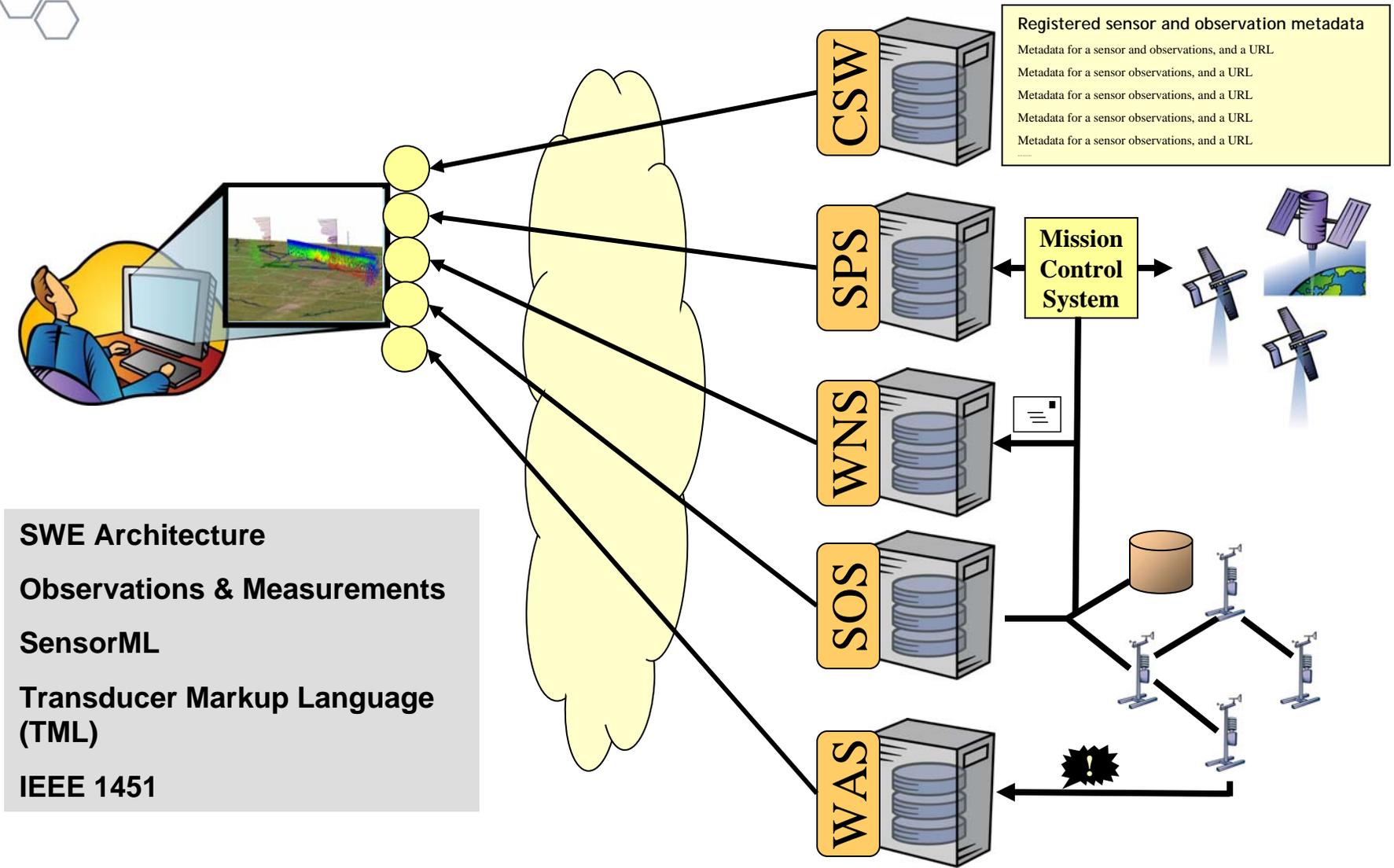
**Sensor Observation Service (SOS)**

**Sensor Planning Service (SPS)**

## Sensor Web



# Enabling Sensor Webs with SWE Framework



**SWE Architecture**  
**Observations & Measurements**  
**SensorML**  
**Transducer Markup Language (TML)**  
**IEEE 1451**



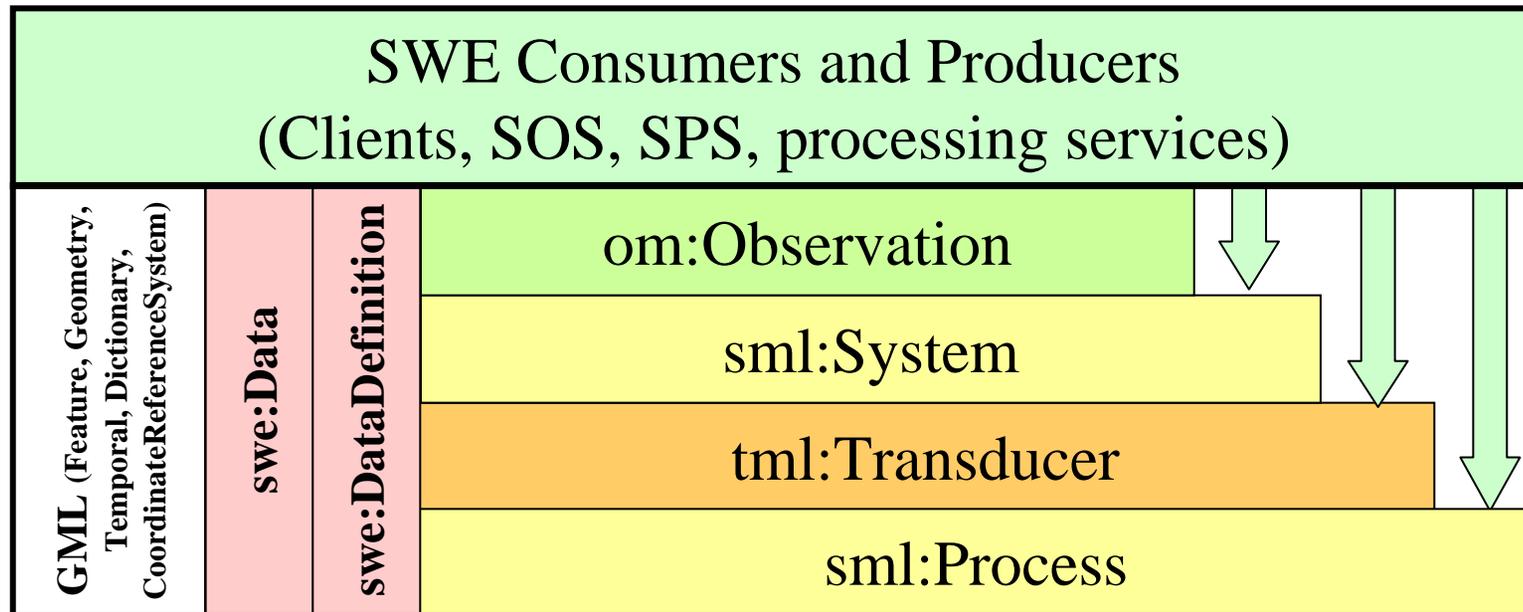
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# SWE Participants and Work items



- **SWE Information Engineering**
  - 3eTI (IEEE 1451)
  - CSIRO (GML, O&M, ISO 19130)
  - IRIS (TML)
  - Univ. Alabama Huntsville (UAH), (SensorML, ISO 19130)
  - Univ. Muenster IFGI (SPS messages)
  - ESA/Spot: in-kind
  - NGA: in-kind
  - NASA Ames: in-kind
- **Sensor Observation Service (SOS)**
  - 3eTI
  - IRIS
  - UAH
  - IFGI
- **SWE Client**
  - York Univ./GeoTango
  - Univ. Alabama Huntsville (UAH)
- **Sensor Planning Service (SPS)**
  - Univ. Muenster/IFGI
  - NASA Ames: in-kind
  - Spot/ESA: in-kind
- **SWE Demonstration**
  - York
  - Intergraph
  - 3eTI
  - UAH
  - IRIS
  - IFGI
  - NASA Ames: in-kind
  - ESA/Spot: in-kind
  - SAS IE coordination

# SWE Information Model



om: Observation and Measurements

sml: Sensor Markup Language

Tml: Transducer Markup Language

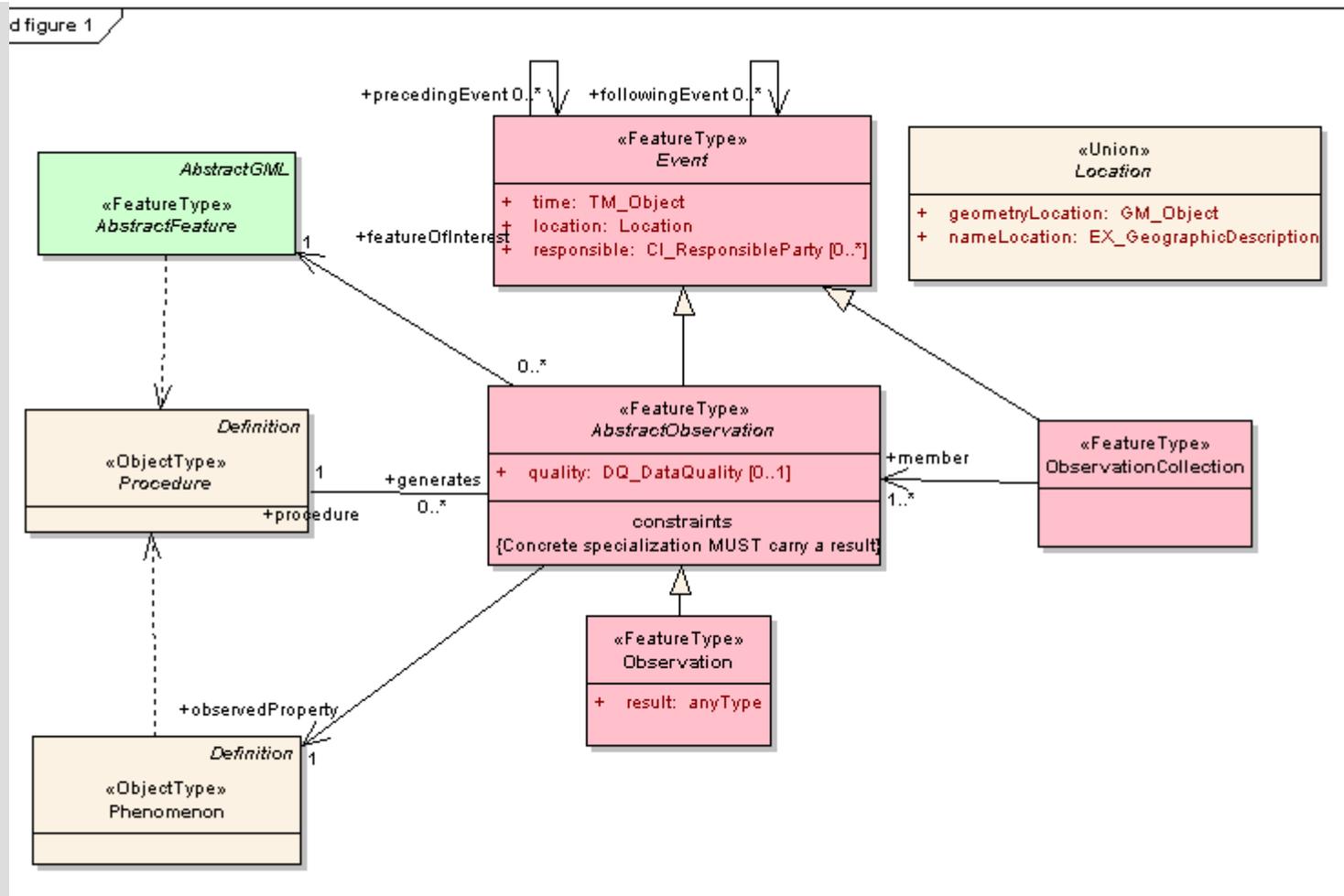
IEEE 1451 Smart Transducer - TEDS

ISO 19130 Sensor and Data Model for Imagery

# Observation and Measurement (OGC 05-087)



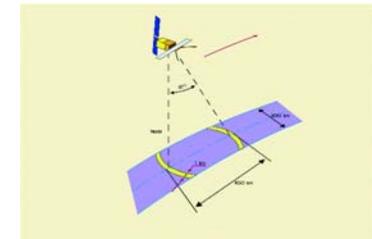
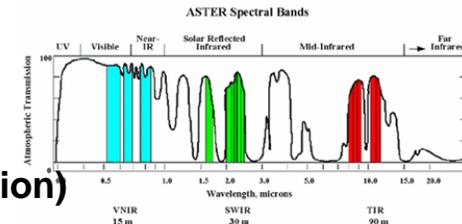
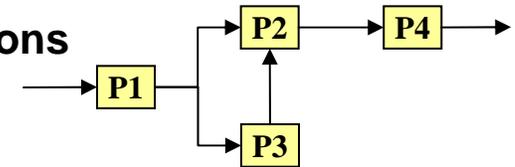
- Observation → Act of estimating a value of a phenomenon, involving a procedure, instrument or algorithm
- Defines the information model for SWE
- Consistent with Measurement Theory
- Consistent with OGC GML and Feature Model



# Sensor Model Language (SensorML) (OGC 05-086)



- Process Model and Process Chains
  - Framework for process models and chains as serializations of executable components.
  - All processes include inputs, outputs, and parameters
- System Description
  - System provides connectivity of a process chain to the real-world by including position information.
  - Geometry Characteristics
    - Size, shape, spatial weight function (e.g. point spread function) of individual samples
    - Geometric and temporal characteristics of sample collections (e.g. scans or arrays)
  - Documentation
    - Overall information about the system
    - History and reference information
- Observation characteristics
  - Physical properties measured (e.g. radiometry, temperature, concentration, etc.)
  - Quality characteristics (e.g. accuracy, precision)
  - Response characteristics (e.g. spectral curve, temporal response, etc.)





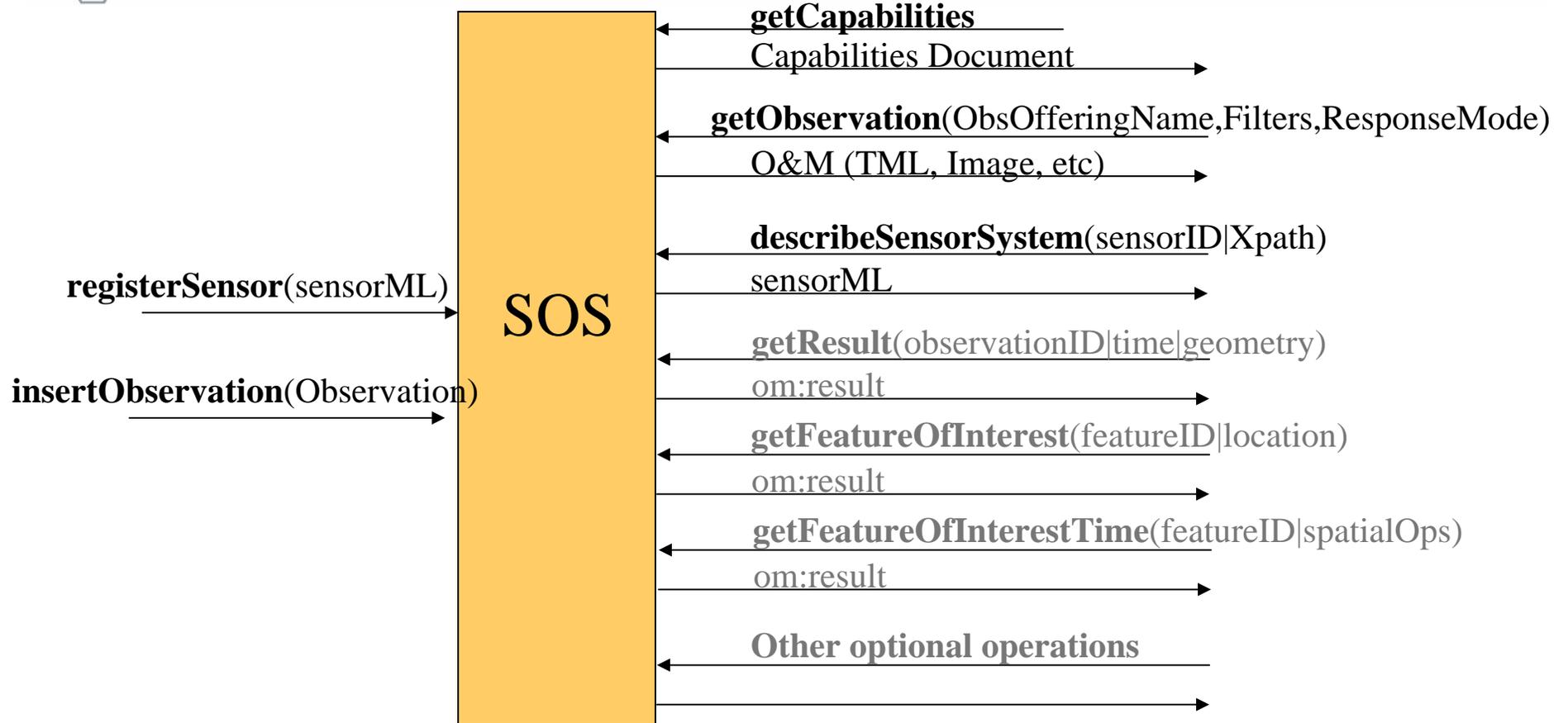


# SWE Services

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- Sensor Observation Service (SOS)
- Sensor Planning Service (SPS)
- SWE Registry
- *Sensor Alert Service (SAS)*
- *Web Notification Service (WNS)*

# Sensor Observation Service (SOS) (OGC 05-088r1)



SOS provides access to sensor system, observations and measurement data via a spatio-temporal query.

# SOS Reference Model



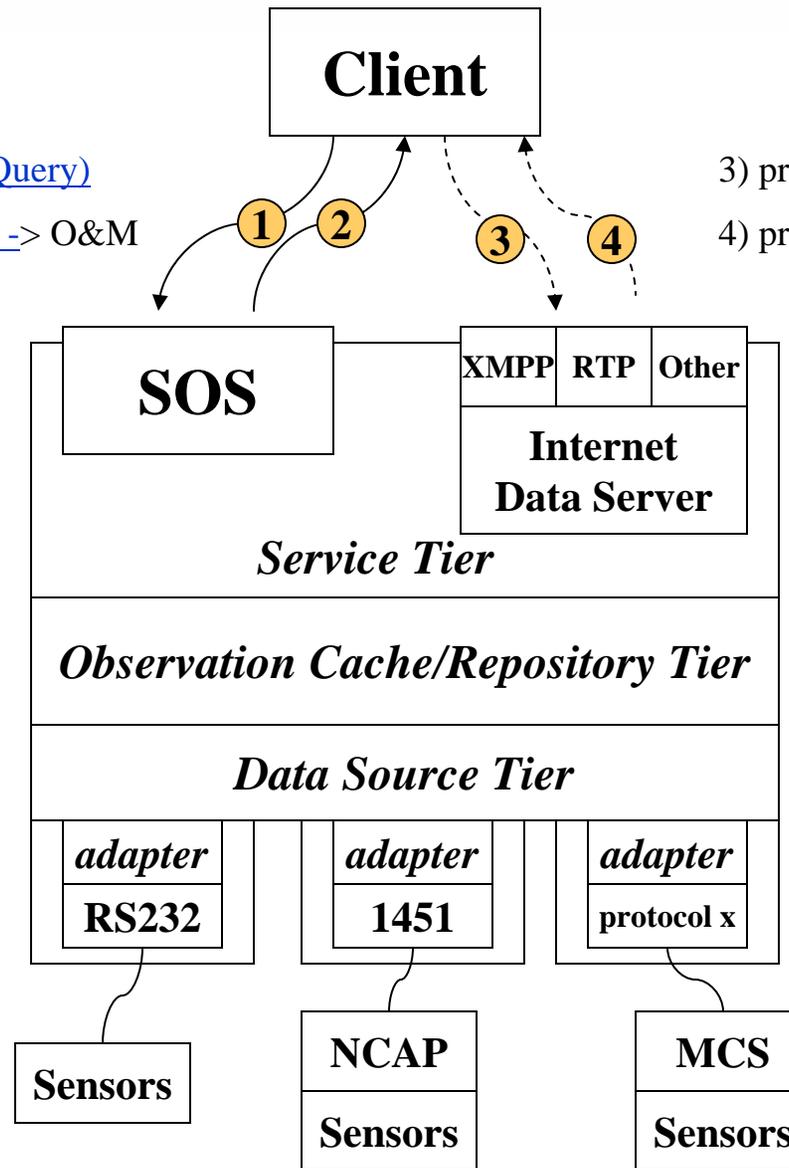
1) [http://GetObservationRequest\(Query\)](http://GetObservationRequest(Query))

2) <http://GetObservationResponse> -> O&M

3) protocol://request (URI)

4) protocol://data (MIME, other)

*Note: All or parts of the components shown here can be separately distributed on networks. Details of this distribution are implementation choices. Italicized elements are abstract and their realizations are opaque to client.*



*Note: Steps 3 & 4, provisioned by an "Internet Data Server", are optional and only required if Observation returned in Step 2 is of type "ResultPointerObservation" (i.e., out-of-band result).*

*Note: An Internet Data Server makes different types of data available via a variety of protocols and data representations. Support for Internet standards are critical.*

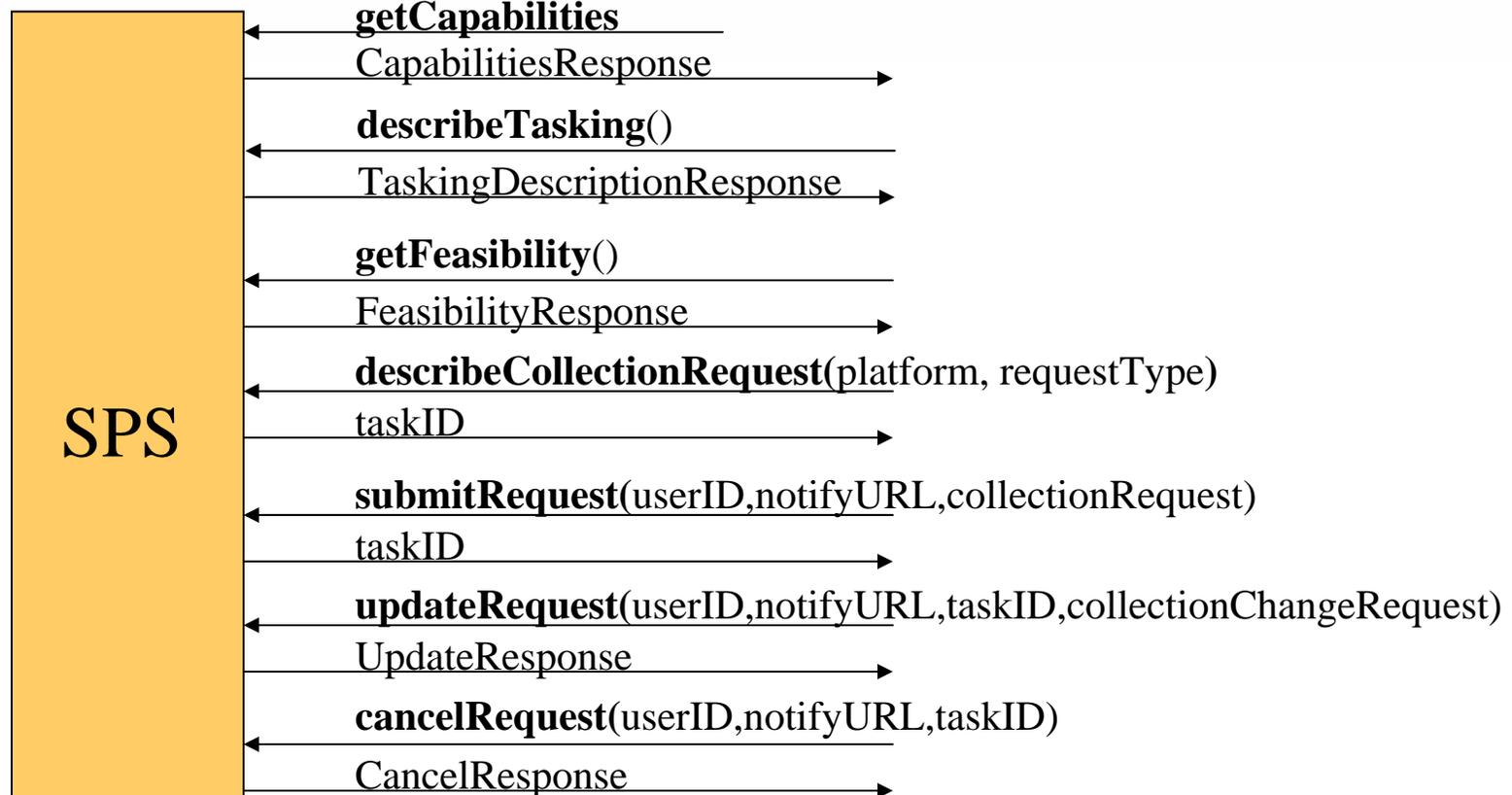
*Note: MCS = Mission Control System (e.g., proprietary or legacy); NCAP = IEEE-1451 Network Capable Application Processor  
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Sensor System Tier





# Sensor Planning Service (SPS) (OGC 05-089r1)

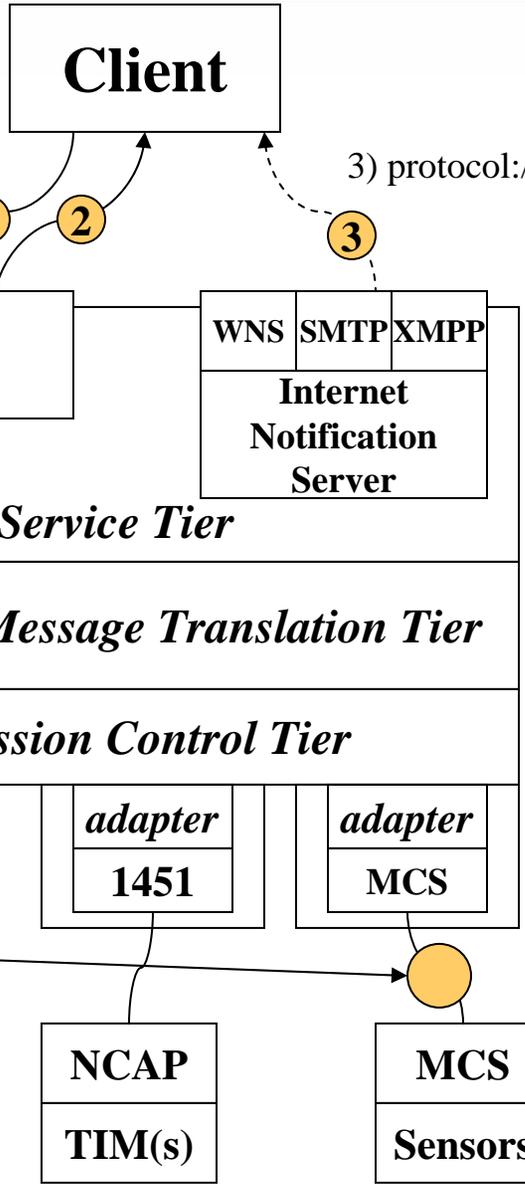


SPS is used to determine collection feasibility for a desired set of collection requests for one or more sensor systems and to submit collection requests directly to these sensors systems.

# SPS Reference Model



- 1) <http://GetFeasibilityRequest>  
<http://DescribeCollectionReques>  
<http://SubmitRequest>  
<http://UpdateRequest>  
<http://GetStatusRequest>  
<http://CancelRequest>
- 2) Request response



*Note: All or parts of the components shown here can be separately distributed on networks. Details of this distribution are implementation choices. Italicized elements are abstract and their realizations are opaque to client.*

*Note: Step 3, provisioned by an "Internet Notification Server", are optional (only if required).*

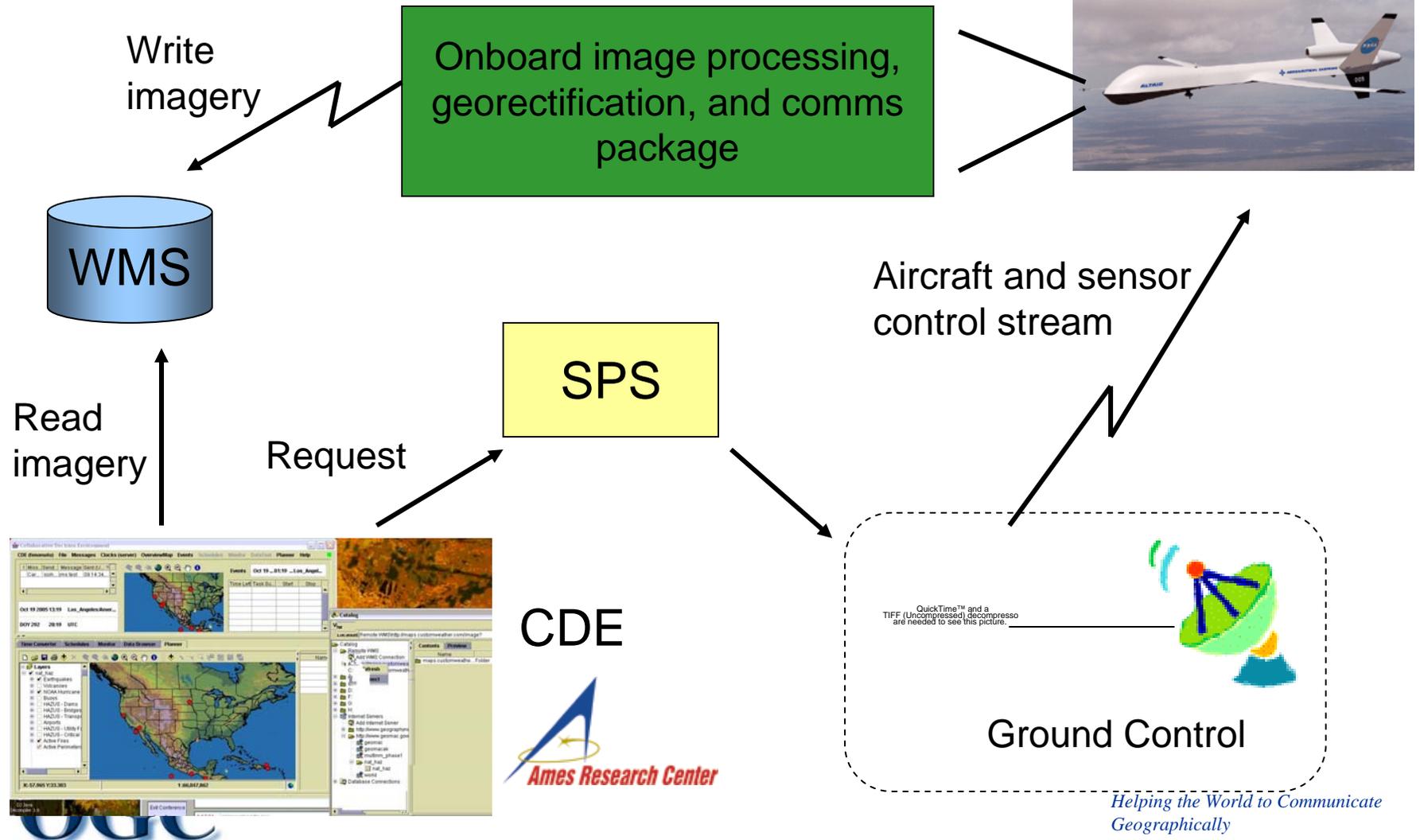
*Note: An Internet Notification Server makes different types of data notifications via a variety of protocols and representations. Support for Internet standards are critical.*

*Sensor Collection Task Message (SCTM)*

*Sensor System Tier*

*Note: MCS = Mission Control System (e.g., proprietary or legacy); NCAP = IEEE-1451 Network Capable Application Processor*





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# OWS-3 Demonstration

-

## October 2005

# The Scenario

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An Emergency Response Center in Southern California receives notification of a fire in the hills east of San Diego. It threatens to breach an industrial storage facility near some inhabited regions. Recognizing the risk that the resulting plume may contain toxic components in addition to the particulates and combustion products typical of a wildland fire, the professionals act quickly to find and deploy resources to track the plume and evaluate its composition, as well as to support the response effort.

## The Actors:

- NG1 = National Guard #1 at ERC - Refractions
- FS1 = Forest Service #1 at ERC - Intergraph
- NG2 = National Guard #2 at ERC - UAH
- FS2 = Forest Service #1 at ERC - York
- EMT = Emergency Response Team - Skyline

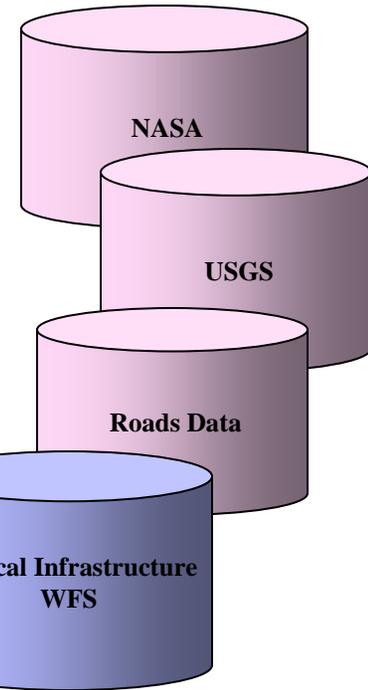
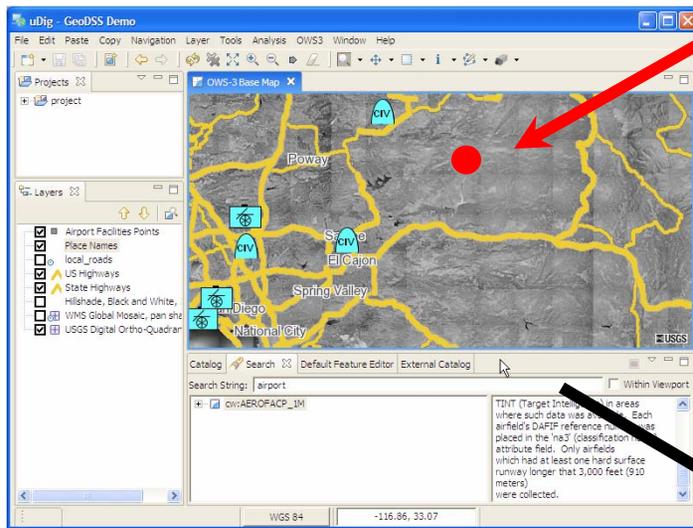
# Scene 1 - Alert / Notification



Alert arrives: probable fire in Pine Hills area

**ALERT**

National Guard builds framework map from various interoperable data sources ...



**CONTEXT**

```
<Map>
  <More Info>
    <abc>
      def
    </abc>
  </More Info>
</Map>
```

... saves sharable context document



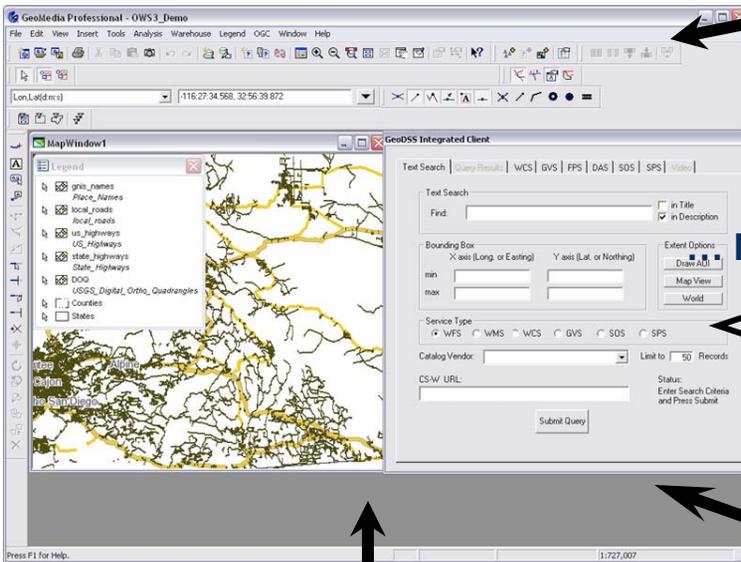
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# Scene 1 Establish Common Operational Picture

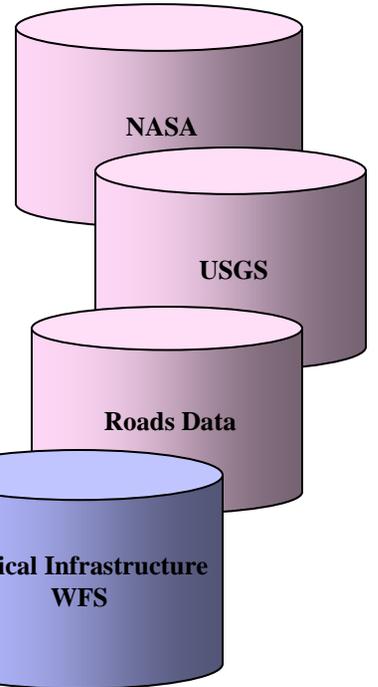


Forest Service reads context document ...

```
<Map>
  <More Info>
    <abc>
      def
    </abc>
  </More Info>
</Map>
```



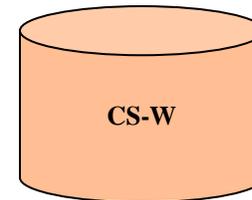
loads data to present same view



... queries symbol catalog



...and translates using Data Aggregation Service

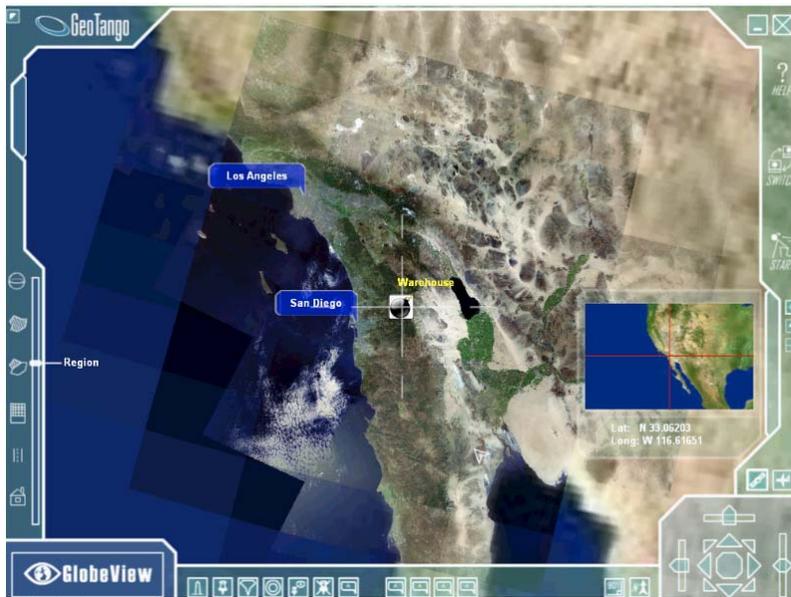


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# Scene 1

## Establish Common Operational Picture ...

National Guard and Forest Service use their Sensor Web (SWE) clients to view Area of Interest from high-altitude ...



“Forest Service” SWE Client

... and zoomed-in perspectives



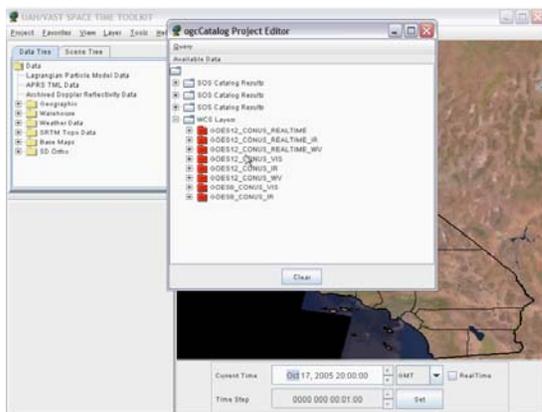
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# Scene 2

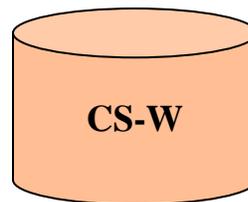
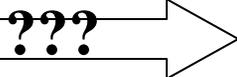
## Prepare to Deploy - Identify Resources



Web Cam

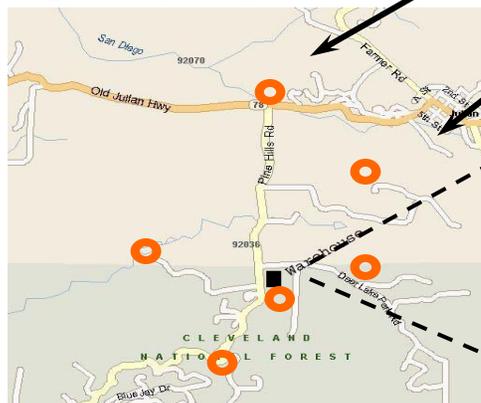


Query for  
sensor  
systems

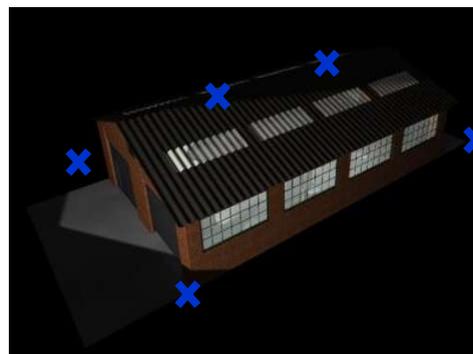


UAV-Based Cameras  
and Scanners

Proprietary Maps



Smoke / Heat Detectors

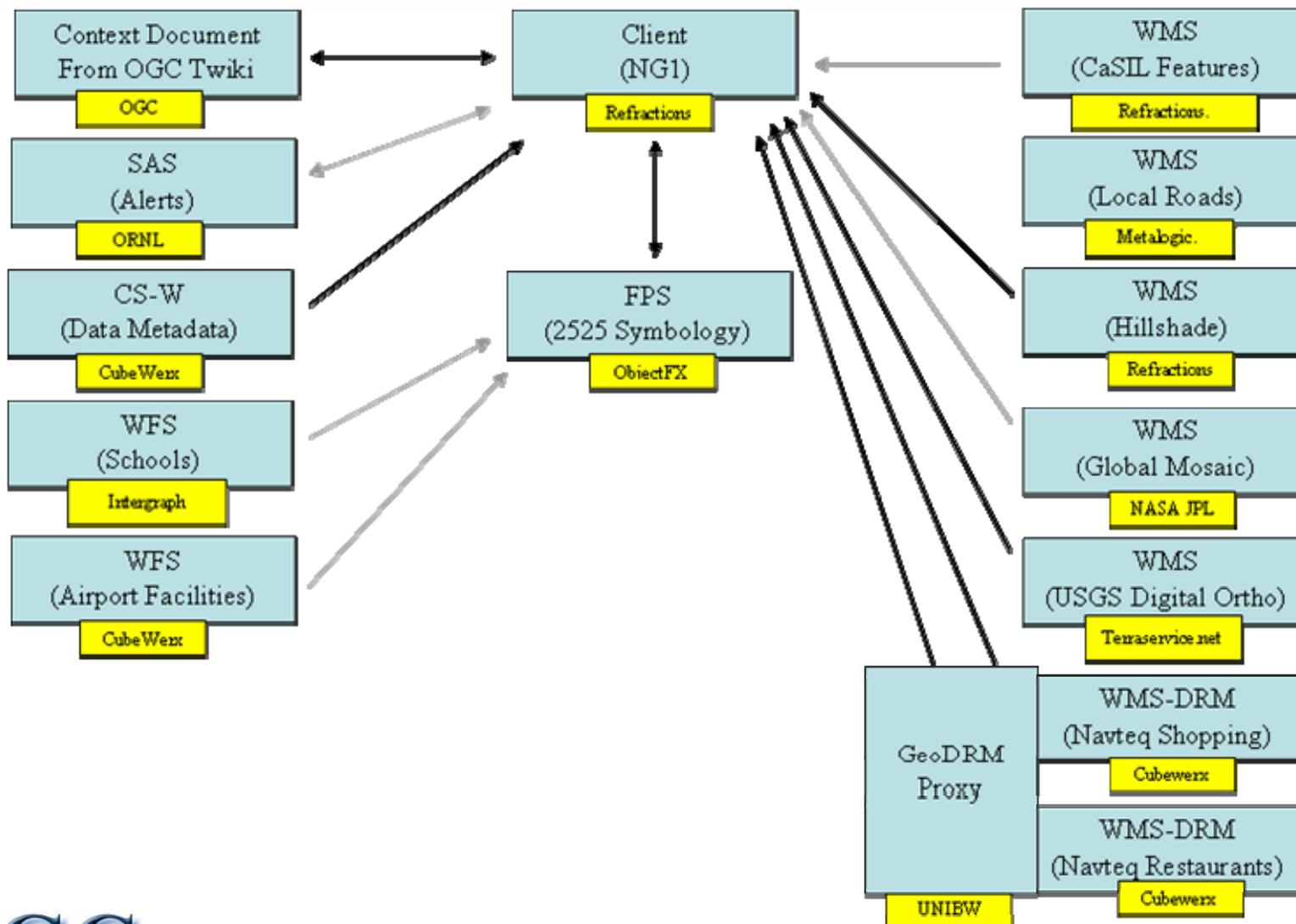


Airborne Toxin Sensors



Mobile Video Unit

# National Guard adding data, including GeoDRM





University of Federal Armed Forces, Munich: OWS3.GeoDRM Demo - Mozilla Firefox Beta 1

File Edit View Go Bookmarks Tools Help

der Bundeswehr  
**Universität München**

# OWS3 Demo - WMS

Demo > Terms and Conditions Management Console

Welcome!  
Your user name / session ID is: **ng1**

Below you can see the Terms Of Use that apply to the different layers of the WMS:

License Name	Layers	Status
Navteq License	<ul style="list-style-type: none"><li>• RESTRNTS:Navteq</li><li>• SHOPPING:Navteq</li></ul>	<p>You did NOT agree to this license.</p>  <p><a href="#">Click here to read the license.</a></p>

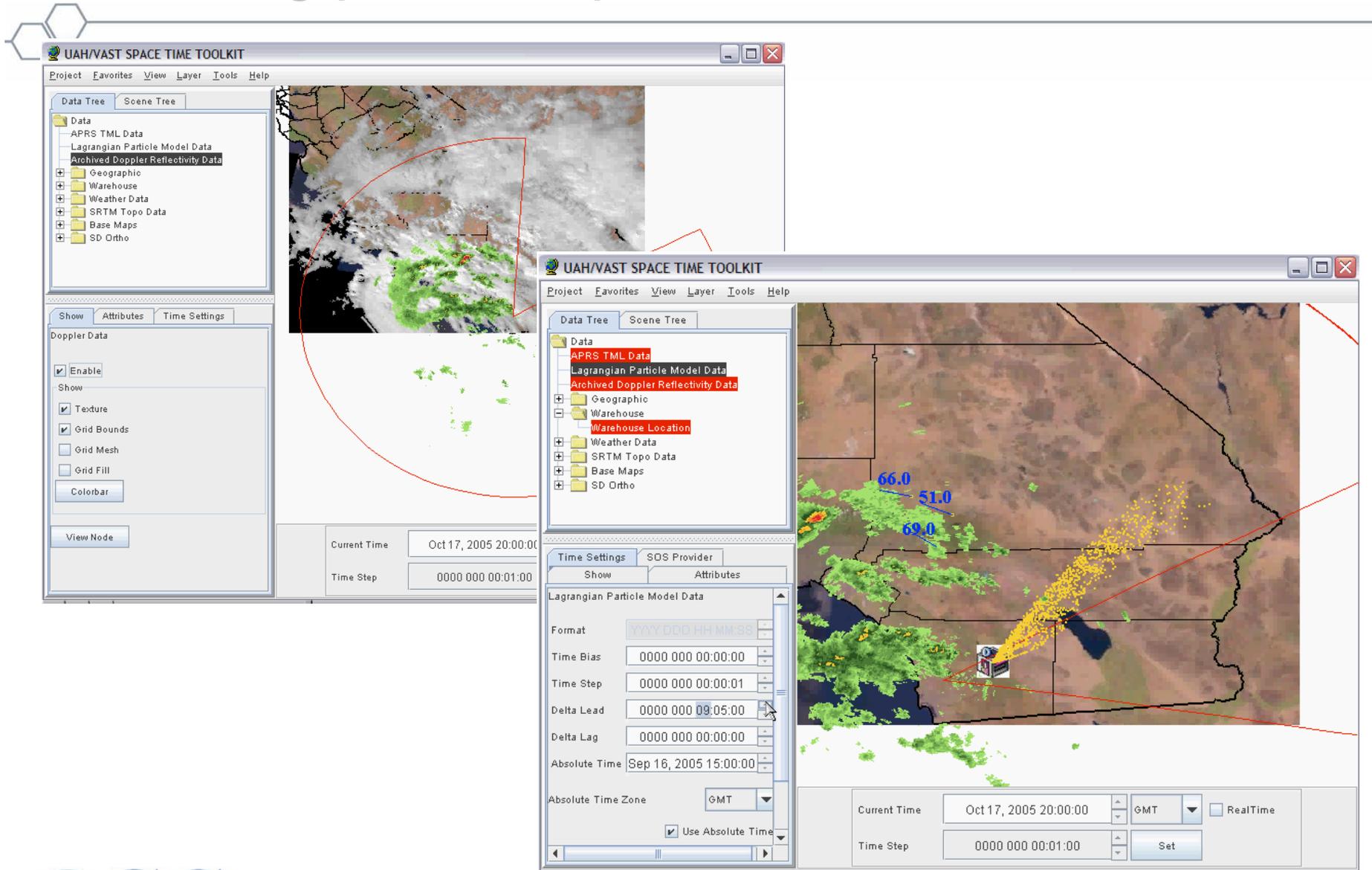
Terms of use not agreed exception



de.ubm.ows3.server.exceptions.DisclaimerNotAgreedException: RESTRNTS:Navteq

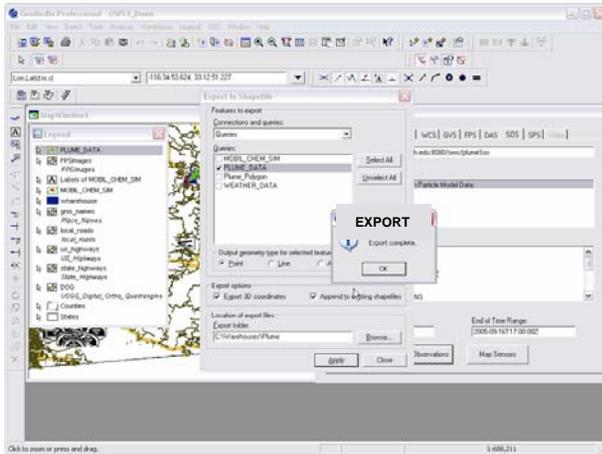
Done

# Predicting potential plume with Weather Radar

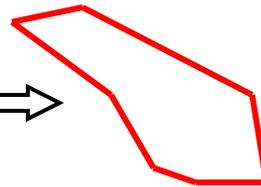


# Scene 3 Plan Deployment

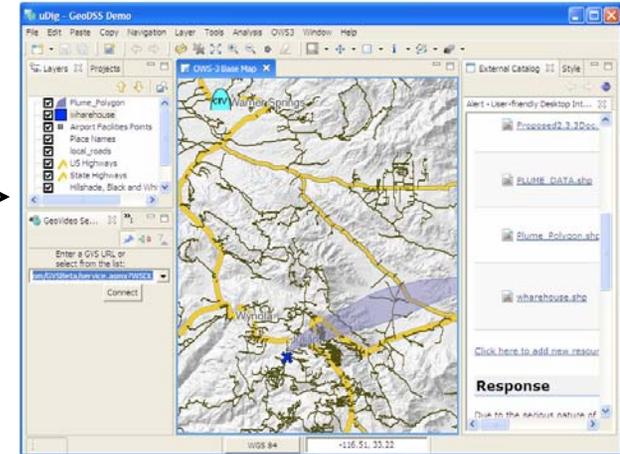
Sensor Client detects plume, develops polygon representation ...



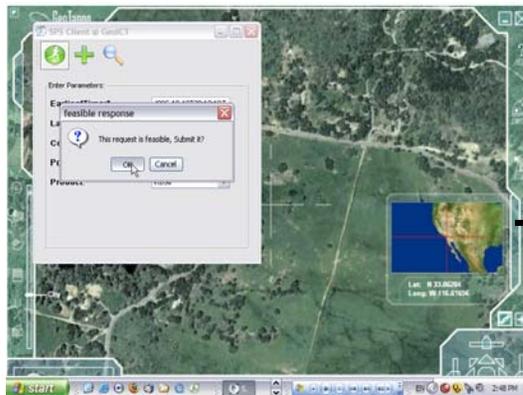
Analysis



... for viewing in DSS Client  
... to develop evacuation areas  
... and avoidance zones for ERT



Deploy  
Emergency Response Team  
&  
Task UAV



# Deploy and Track Emergency Responders

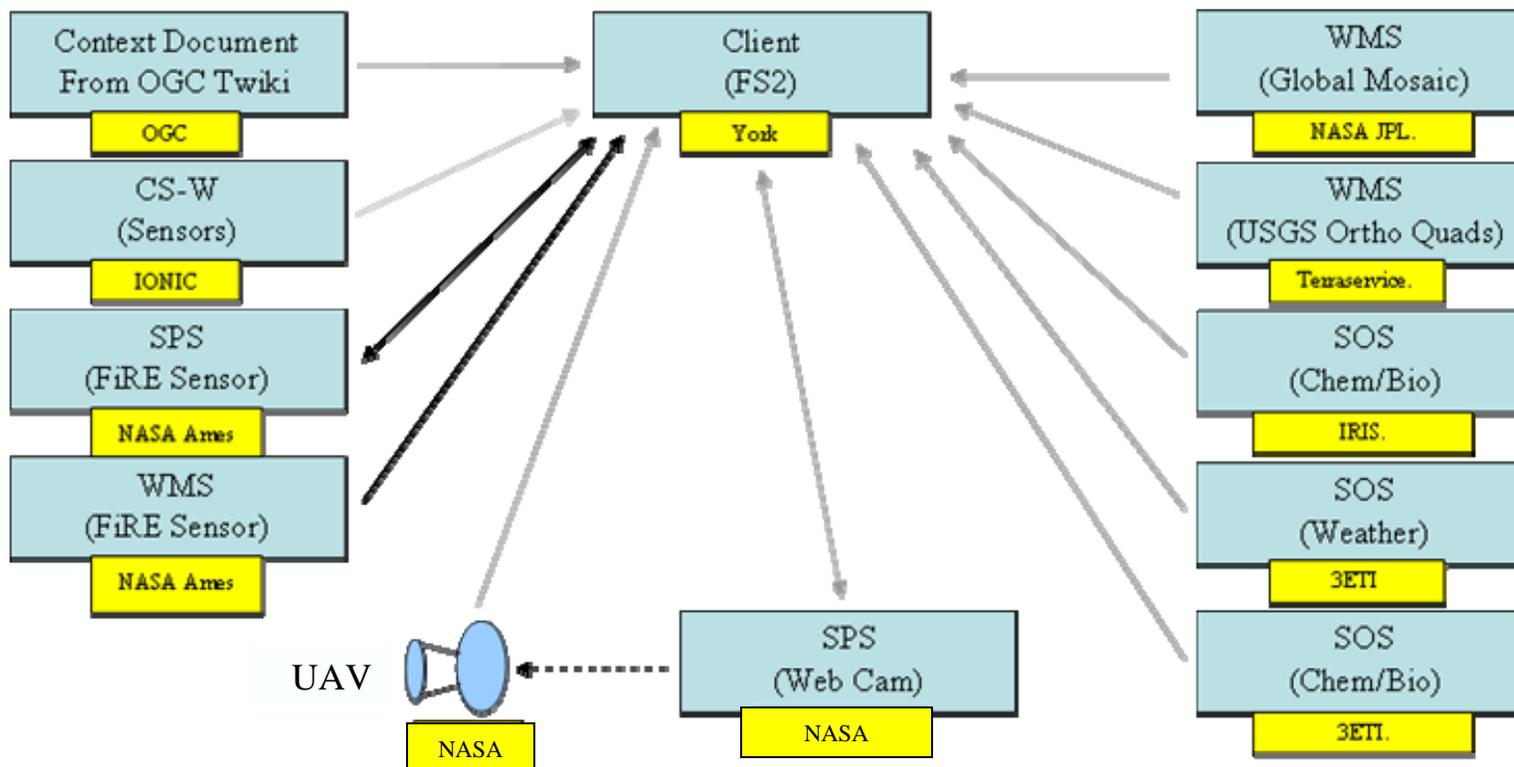


The screenshot displays the uDig - GeoDSS Demo application interface. The main window shows a map titled "OWS-3 Base Map" with several cyan circular markers labeled "CIV" representing emergency responders. A red dashed line indicates a path or route on the map. The left sidebar contains a "Layers" panel with a list of layers: road\_selection, Camera Location, Plume\_Polygon, warehouse, Airport Facilities Points, Place Names, local\_roads, and US Highways. Below the layers is a "GeoVideo Se..." panel with a table of data.

ID	Description	Loc
6	take dog to therapy	http:
7	road rip after	http:
8	off to therapist	http:
9	off to movie	http:
10	left theatre	http:
11	to lulu's happy hour	http:
12	take dog to therapy	http:
13	take dog to therapy	http:
14	take dog to therapy	http:
15	visit the Dalai Lama	http:
16	road trip	mm:
17	to grandma's house	mm:
18	chasing tornadoes	mm:
19	road trip before	mm:
20	take dog to therapy	mm:

At the bottom of the application, there is a status bar with the text "Select a different layer and try again", the coordinate system "WGS 84", and the coordinates "-116.55, 32.57". On the right side, there is a "GeoVideo View" window showing a video feed of a road. The video player controls at the bottom indicate "Playing: 301 K bits/second" and a duration of "03:04".

# Forest Service Client Tasks NASA SPS



# Sensor Planning Service for NASA UAV



QControl

File

Server:  Port:

Server Options Task Options

ID:

Status:

Earliest Collection Time:

Latest Collection Time:

Scheduled Event Time:

 National Aeronautics and Space Administration

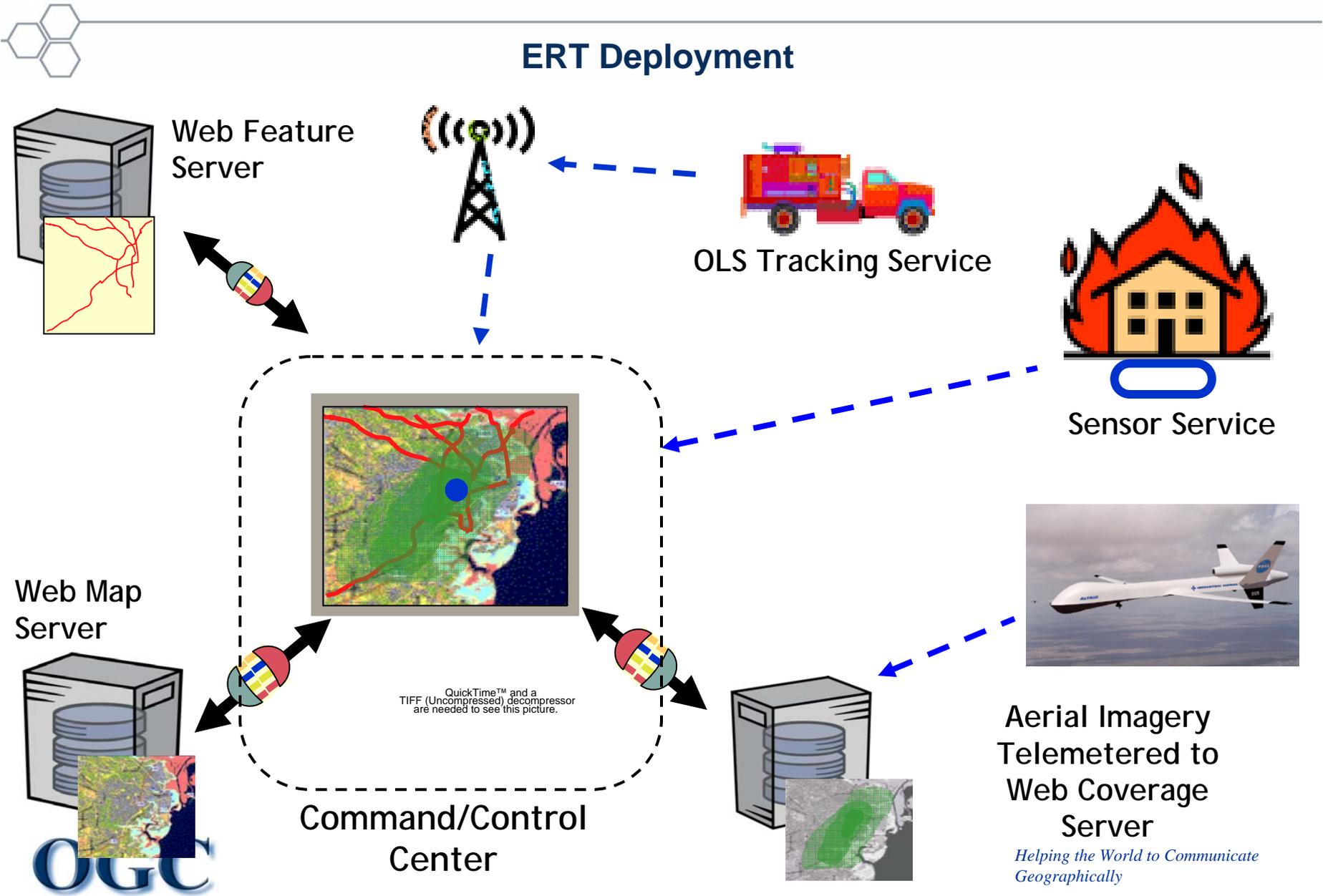
 Ames Research Center

# UAV swath over DRG over Terrain

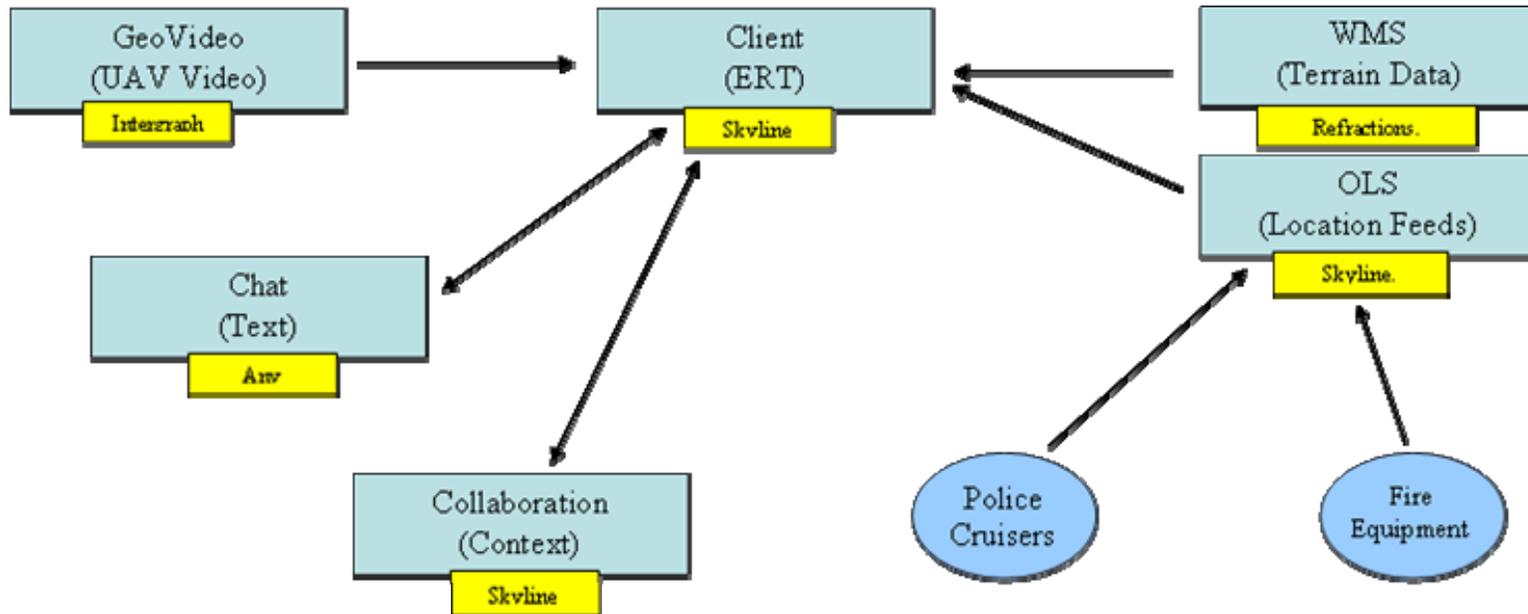


# Scene 4

## ERT Deployment



# 4.1 Emergency Response Team



# Tracking service and terrain view



The screenshot displays the Skyline TerraExplorer Pro software interface. The main window title is "TerraExplorer Pro - C:\california-san diego\USA-San Diego features.FLY". The interface includes a menu bar (File, Edit, View, Navigation, Create, Measurements, Tools, Help) and a toolbar with various icons. On the left, the "Information" panel shows a tree view with folders like Major\_Cities, US\_States, Countries, OLS Entities, and WFS\_DISTRICTS, and a list of features including "Fire Start Point" and "Fire heading here". The central 3D view shows a terrain map with a red "Fire Start Point" label and a "PoliceCruiser1" label. The bottom left panel shows a 2D map view with a "US Map" tab and a "MapMarker" tab, displaying a map of Julian, California, with a black arrow pointing to a location. The bottom right panel shows a "FLIGHT PANEL" with a "Buffering" progress bar and a speed indicator of "0.0 Kbps".



# UAV Video over Terrain



The screenshot displays the Skyline TerraExplorer Pro interface. The main window shows a 3D terrain view with a UAV camera frustum (a grey rectangle with a white arrow) positioned over a green field. The interface includes a menu bar (File, Edit, View, Navigation, Create, Measurements, Tools, Help), a toolbar with various icons, and a left-hand panel with the following sections:

- Information:** A tree view showing folders like Major\_Cities, US\_States, Countries, OLS Entities, and WFS\_DISTRICTS, along with checked items like Fire Start Point, Fire heading here, and SanDiegoAerial.
- GeoVideo Service:** A configuration panel with fields for Server URL (http://www.geovideoserv), Load (Regional view only), a Connect button, and a dropdown menu set to San Diego : Aerial.

At the bottom right, there is a **FLIGHT PANEL** with a Buffering progress indicator (0.0 Kbps) and navigation controls.

# NG continues to monitor after situation is secured

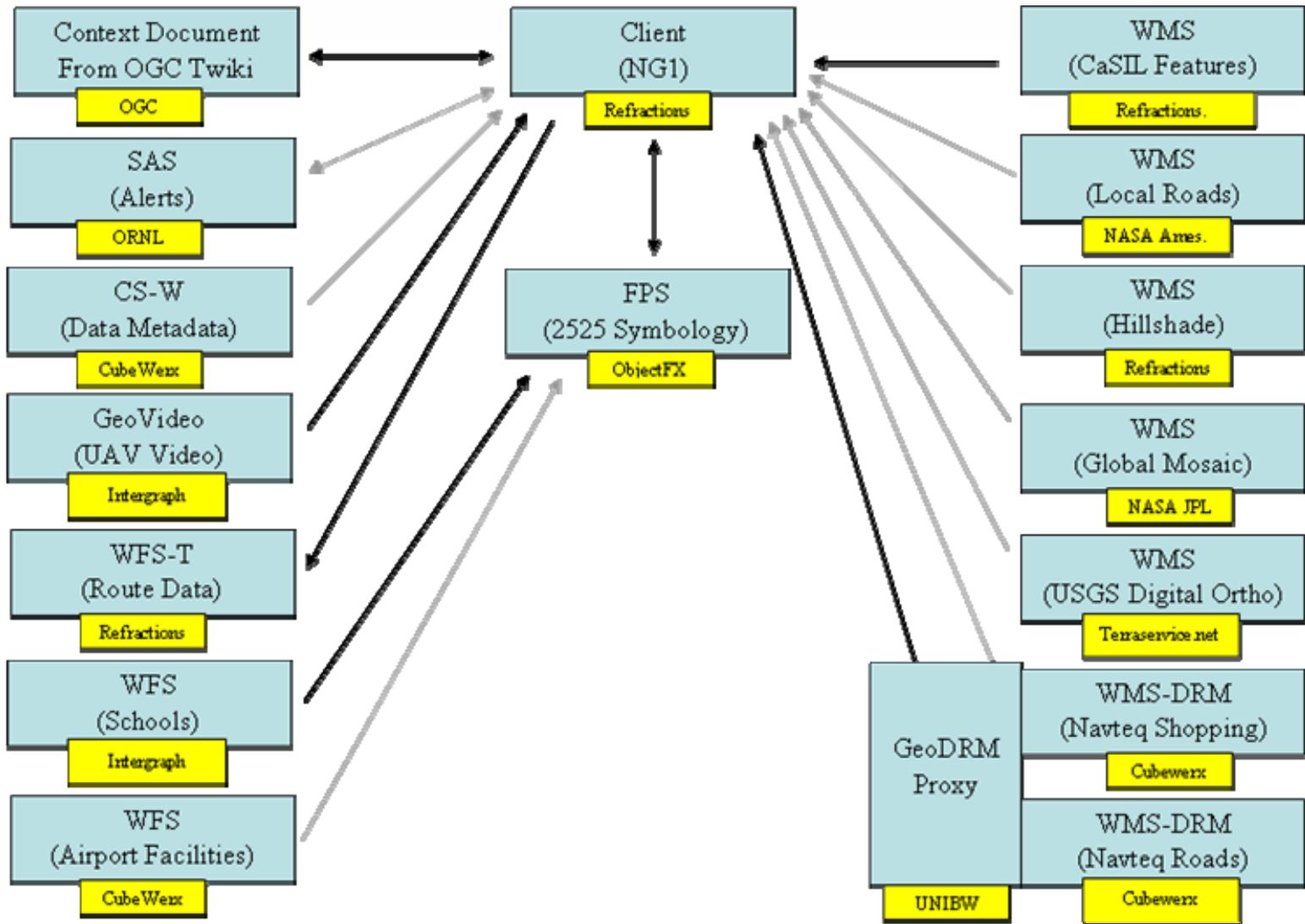


ID	Description	Loc
17	to grandma's house	mm:
18	chasing tornadoes	mm:
19	road trip before	mm:
20	take dog to therapy	mm:
21	take dog to therapy	mm:
22	road rip after	mm:
23	off to therapist	mm:
24	off to movie	mm:
25	left theatre	mm:
26	to lulu's happy hour	mm:
27	take dog to therapy	mm:
28	take dog to therapy	mm:
29	take dog to therapy	mm:
30	visit the Dalai Lama	mm:

WGS 84 -116.60, 33.20

Review UAV over location - note red dot

# 4.4 NG1 (Refractions)



# Sensor Web Concept



**SWE Architecture**

**Observations & Measurements**

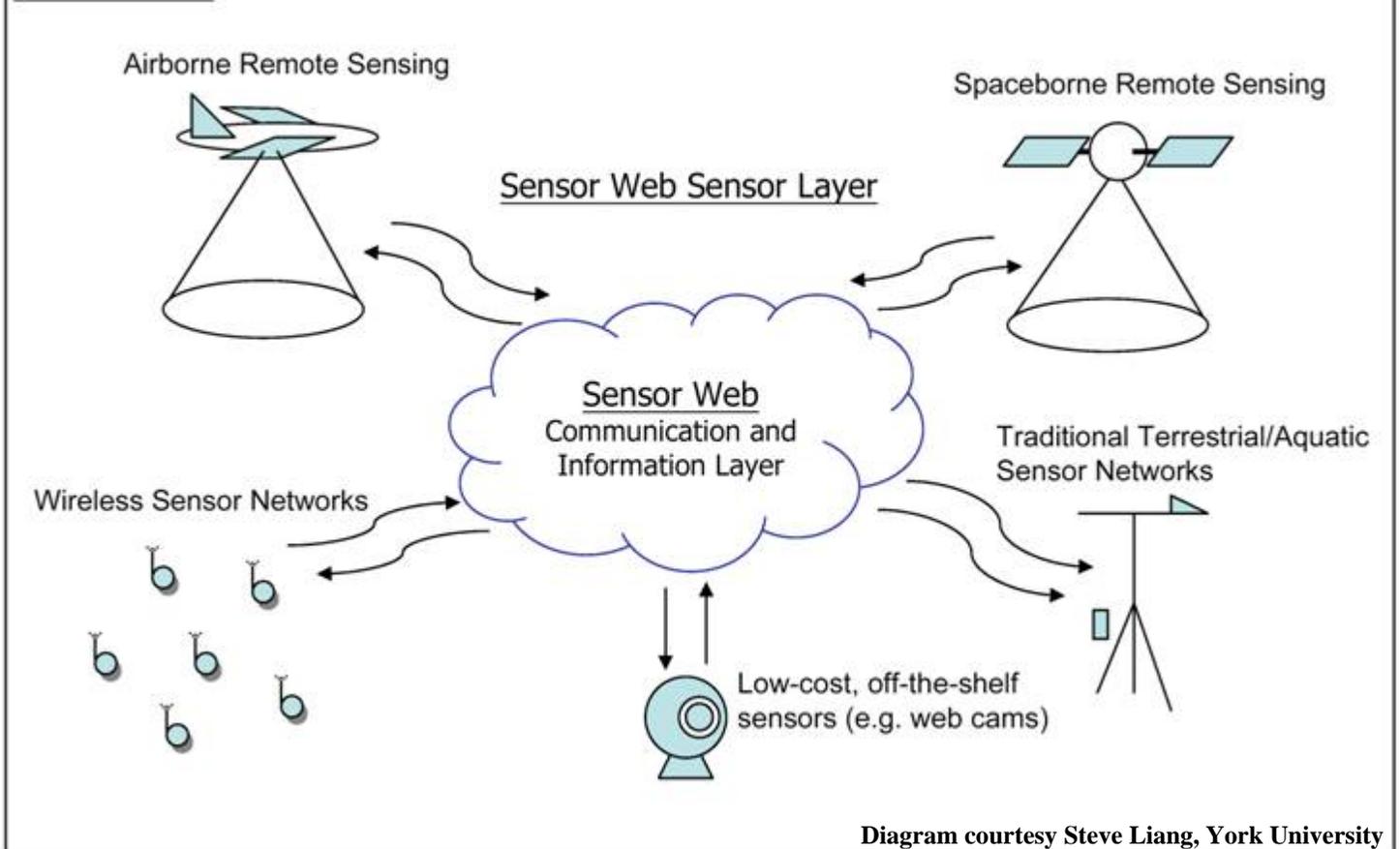
**SensorML**

**Transducer Markup Language (TML)**

**Sensor Observation Service (SOS)**

**Sensor Planning Service (SPS)**

## Sensor Web



# Questions?



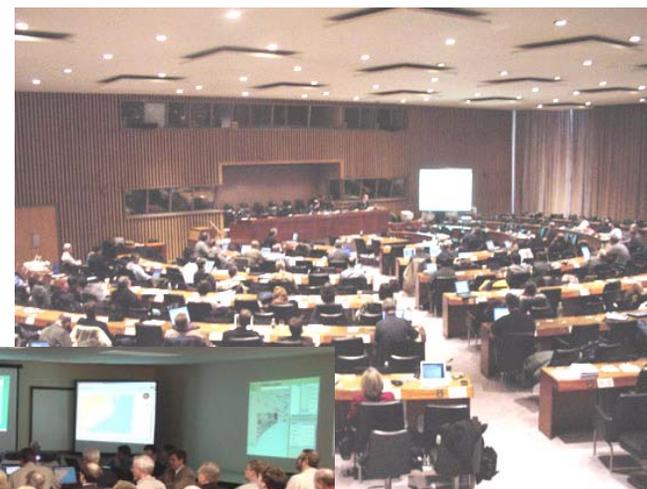
George Percivall

[percivall@opengeospatial.org](mailto:percivall@opengeospatial.org)

(301) 560-6439

Open Geospatial  
Consortium, Inc

[www.opengeospatial.org](http://www.opengeospatial.org)



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