Satellites

Int’l

Users

Int’l

Disasters

NASA

SensorWeb

Project
For big software projects, cost is a function of amount of code.
Our Reality...
But we have made some good progress...
Number of OGC Standards Has Increased Significantly

which would increase our cost!

2005 ... 2010

# OGC Standards
So Our OGC Compliance Has Decreased

OGC Compliance

2005 ... 2010
General Approach

• Goal: Enable user to cost-effectively find and create customized data products to help manage disasters
  • On-demand
  • Low cost and non-specialized tools such as Google Earth and browsers
  • Access via open network but with sufficient security
• Use standards to interface various sensors and resultant data
  • Wrap sensors in Open Geospatial Consortium (OGC) standards
  • Wrap data processing algorithms and servers with OGC standards
  • Use standardized workflows to orchestrate and script the creation of these data products
• Target Web 2.0 mass market
  • Make it simple and easy to use
  • Leverage new capabilities and tools that are emerging
  • Improve speed and responsiveness
SensorWeb High Level Architecture

- Data Processing Node
  - Web Coordinate Transformation Service (WCTS)
  - Web Processing Service (WPS)
  - Web Coverage Service (WCS)

- Web Map Service (WMS)
- Web Feature Service (WFS)
- Web Coverage Processing Service (WCPS)

- OGC Pub/Sub Service (OPSB)
- Sensor Observation Service (SOS)
- GeoTorrent Distribution Service

- EO-1 Satellite
- In-situ Sensor Data Node
- UAV Sensor Data Node
- SWE Node

- Floods, fires, volcanoes etc

- Campaign Manager API
- RSS Feeds
- Campaign Manager
- Workflows

- Identity Management Service (OpenID 2.0)

Components outlined in red are part of NASA generic SensorWeb toolbox.
Present NASA SensorWeb 2.0

SPS = Sensor Planning Service
OPSB = OGC Publish/Subscribe Basic
WfCS = Workflow Coverage Service
WCS = Web Coverage Service
WCPS = Web Coverage Processing Service
WPS = Web Processing Service

EO-1 & HyspIRI Testbed

Data
Dynamic SWAMO Agent Upload

Asynchronous Message Queue Protocol

ENVI/IDL

WCPS backend components
NASA SensorWeb 3.0 Approach

SPS = Sensor Planning Service
OPSB = OGC Publish/Subscribe Basic
WfCS = Workflow Coverage Service
WCS = Web Coverage Service
WCPS = Web Coverage Processing Service
WPS = Web Processing Service

Get Feasibilities
Submit Task

Task

Alerts & Notifications
OPSB
GeoTorrent

Distribute data via file share

Execute Workflow
Data Atom Feed
Create/Visualize Workflows

WfCS

Execute Algorithm
Custom Products
Create/Visualize Algorithms

WPS

Composite

WPS

ENVI/IDL

Custom Products
Create/Visualize Algorithms

Data Atom Feed
Dynamic Message Queue Protocol
Asynchronous Message Queue Protocol

EO-1 & HyspIRI Testbed

Gnu C Compiler/Linker
Parser/Code Generator

WCPS backend components
NASA SensorWeb 3.0 Unified Restful Interface with Security

RESTful / Secure Application Process Interface (API)

Resources
- GetFeasibilities
- SubmitTask

Flows
- Composite
- Algorithms

Service Document
Get, Post, Put, Delete
Atom Feeds

2-Factor Authentication

Security / OpenID / OAuth

Distributed Security Providers

Data
EO-1 & HyspIRI Testbed

Other Nodes

12
One Example of Decreased Complexity to Develop Application Processing Interfaces (API’s)

REST RPC bindings specifications

<table>
<thead>
<tr>
<th>Interfaces for SensorWeb 2.0</th>
<th>Pages for specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPS 1.0</td>
<td>186</td>
</tr>
<tr>
<td>WPS 1.0</td>
<td>73</td>
</tr>
<tr>
<td>WCPS 1.0</td>
<td>66</td>
</tr>
</tbody>
</table>

RESTful binds (aka AtomPub specifications)

<table>
<thead>
<tr>
<th>Interfaces for SensorWeb 3.0</th>
<th>Pages for specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consolidated RESTful API</td>
<td>27</td>
</tr>
</tbody>
</table>

Comparison does not include SOS, WNS/SAS, WFS, WfCS…. Increased complexity is a barrier to entry for development, sustaining engineering and usage.
Examples of SensorWeb Usage for Disasters
The 2009 Disaster

- In February and March 2009, torrential rains increased water levels in the Zambezi, Okavango, Cunene and Chobe Rivers.
- This led to a 40-year flood in the Caprivi, Kavango and Cuvelai basins, affecting some 750,000 people (37.5% of the population of Namibia)
- Whole villages were cut off and had to be relocated into camps. Some 50,000 people were displaced
- Livestock were stranded and died of hunger
- 102 people died
Flooded village in Northern Namibia viewed from helicopter by expert team during workshop in January 2010 (Photo: Dr. Joerg Szarzynski)
Formation of Flood-Disease Early Warning Project

- Against this background, major goal of the Namibia SensorWeb Pilot Project is a scientifically sound, operational trans-boundary flood management decision support system for Southern African region to provide useful flood and waterborne disease forecasting tools for local decision makers.

- Pilot Project established under the auspices of:
  - Namibian Ministry of Agriculture Water and Forestry (MAWF), Department of Water Affairs
  - Committee on Earth Observing Satellites (CEOS), Working Group on Information Systems and Services (WGISS)

- Effort consists of identifying and prototyping technology which enables the rapid gathering and dissemination of both space-based and ground sensor data and data products for the purpose of flood disaster management and water-borne disease management.
Timeline of Activities Related to Namibia Early Warning Flood Project

2008
- 1st Charter activation
- 2nd UN-SPIDER Bonn WS

2009
- 1st Technical Advisory Mission
- 3rd Charter call
- Technical Expert Meeting Bonn

2010
- Regional Meeting Namibia
- 3rd UN-SPIDER Bonn WS
Flood SensorWeb Workshop Held in Winhoek, Namibia in January 2010

Front Row: left to right, Gail D. Mathieu, U.S. Ambassador to Namibia, John Mutorwa, Minister of Ministry of Agriculture, Watery and Forestry (MAWF) and Kari Egge, UN Resident Coordinator in Namibia

The following agencies contributed to establish an international expert team and sent representatives to this field mission:
European Commission, Joint Research Center (JRC), Italy; German Aerospace Center (DLR), Germany; German Technical Cooperation (GTZ), Windhoek, Namibia; International Institute for Geo-Information Science and Earth Observation (ITC), University of Twente, The Netherlands; National Aeronautics and Space Administration (NASA), US; NOAA / National Environmental Satellite Data and Information Service (NESDIS),US; Ukraine Space Research Institute (USRI), Ukraine; UNESCO; United Nations Resident Coordinator, Namibia; United Nations Office for Outer Space Affairs (UNOOSA), Austria/Germany; and World Meteorological Organisation (WMO).
• Namibian Dept of Hydrology installing flood gauges and rain gauges
• Correlating ground measurements with satellite imagery to calibrate imagery and thus improve flood forecast models
Top Level Flood SensorWeb Functional Flow

1. Request for satellite imagery in area of interest
2. Campaign Manager
3. Flood alerts to automated tasking
4. Flood conditions
5. Ground flood measurements
6. Compare to history
7. Improved Flood Prediction Model

*SPS – Sensor Planning Service
Namibian Flood Early Warning Prototype

Namibia Short Term Pilot for 2010

- Colored areas represent catchments where rainfall collects and drains to river basins
- River gauges displayed as small circles
- Detailed measurements are available on the display by clicking on the river gauge stations.
- This display can be viewed and manipulated at:
  [http://geobpms.geobliki.com/namibia](http://geobpms.geobliki.com/namibia) and
  [http://geobpms.geobliki.com/namibia2](http://geobpms.geobliki.com/namibia2)
# Campaign Manager Tasking Request Page

**Visualize request using Google Map**

## Tasking Request:

<table>
<thead>
<tr>
<th>Title:</th>
<th>Lake Liembezi test1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description:</td>
<td>Namibia flood campaign requested by Guido Van Langenhouve</td>
</tr>
<tr>
<td>Category:</td>
<td></td>
</tr>
<tr>
<td>Latitude:</td>
<td>-17.9108028411865</td>
</tr>
<tr>
<td>Longitude:</td>
<td>24.11206221146</td>
</tr>
<tr>
<td>Day/Night:</td>
<td>day time</td>
</tr>
<tr>
<td>Country Code:</td>
<td></td>
</tr>
<tr>
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<td></td>
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<tr>
<td>Admin Code:</td>
<td></td>
</tr>
<tr>
<td>Admin Name:</td>
<td></td>
</tr>
<tr>
<td>Nearby:</td>
<td></td>
</tr>
<tr>
<td>Created At:</td>
<td>Thu, 23 Apr 2009 02:37:14 -0000</td>
</tr>
<tr>
<td>Updated At:</td>
<td>2009-04-23</td>
</tr>
</tbody>
</table>

### Feasibilities
- **Potential Feasibility** Assets:
  - ALOS, Date: 2009-04-24T00:24:50Z
  - FORMOSAT-2, Date: 2009-04-25T00:45:28Z
  - QB-2, Date: 2009-04-25T08:00:21Z
  - SPOT-5, Date: 2009-04-25T21:15:14Z
  - EC-1, Date: 2009-04-27T08:25:00Z
  - FORMOSAT-2, Date: 2009-04-27T12:24:02Z
  - SPOT-5, Date: 2009-04-28T06:24:02Z
  - QB-2, Date: 2009-04-28T19:10:07Z
  - ALOS, Date: 2009-04-29T00:35:33Z
  - EC-1, Date: 2009-04-29T08:04:00Z
  - ALOS, Date: 2009-04-29T20:28:33Z
  - FORMOSAT-2, Date: 2009-04-29T23:19:50Z
  - QB-2, Date: 2009-04-30T02:52:57Z
  - SPOT-5, Date: 2009-04-30T11:02:33Z
  - EC-1, Date: 2009-05-02T00:21:00Z
  - ALOS, Date: 2009-05-02T14:09:28Z
  - QB-2, Date: 2009-05-02T14:38:16Z
  - SPOT-5, Date: 2009-05-03T01:43:33Z
  - FORMOSAT-2, Date: 2009-05-03T09:47:24Z

![Map](Map.png)
Deliver Level 2 Products via News Feeds to Users Along with Links to GeoTiff, KML and information about Image
Another Sample Application:
Disease SensorWeb
Top Level Malaria Early Warning SensorWeb

Functional Flow

- Flood Predictions
- Statistical disease risk alerts
- Flood alerts
- Request for satellite imagery in area of interest
- Climate & vegetation conditions
- Flood conditions
- Campaign Manager
- EFTB
- Historical epidemiological data
- *SPS – Sensor Planning Service

Customized plan of needed satellite images

* May include clouds and shadows.
Malaria risk map identifies priority areas and additional resources needed to fight epidemics effectively.

Strategy: WEATHER PROXY
AUGUST 26, 2008

INTENSIVE MALARIA

Felix Kogan/NOAA/NESDIS
Predicting Malaria in KENYA

VH provides up to 4 months advance malaria warning
NOAA Malaria Risk Indicators Area, southern Africa

Based on Vegetation Health Index system assessment conditions are very favorable (risk level 3 and 4) for malaria epidemic in

Northeast Namibia
Most of Botswana (except south)
Southern Angola
Southeast Zambia
Most of Zimbabwe
Parts of Mozambique
Recent SensorWeb Acquisitions: Oil Slick in Gulf of Mexico and Volcano in Iceland
EO-1 Target
Apr 25th

Oil Spill Initial Location
On Sat., April 17, 2010, the Hyperion instrument onboard NASA's Earth Observing-1 (EO-1) spacecraft obtained this pair of images of the continuing eruption of Iceland's Eyjafjallajökull volcano. In the left-hand image, created from visible wavelengths, new black ash deposits are visible on the ground, as well as nearby brilliant unsullied ice and snow and the volcano's brown, billowing plume. The plume's dark color reflects its large ash content. These fine particles of pulverized rock are carried high into the atmosphere, where they create a hazard for aviation and are carried long distances by the prevailing winds.
Extending SensorWeb
Onboard Satellites:
Detecting Materials
Onboard a Satellite
**Extension of SensorWeb Onboard**

1. **create, edit, test algorithms/classifiers for use onboard space-based sensors**
2. **transform algorithm into mobile agent**
3. **upload mobile agent**
4. **run onboard automatically**
5. **download customized low-latency onboard generated data products**

**HyspIRI Intelligent Payload Module (IPM)**

**Ground Station**

**Image data products- Phil Dennison 2008**
NATO Seizes Tons of Bomb Material in Afghan Raid

Tuesday, November 10, 2009
Associated Press

KABUL — International troops and Afghan police seized 250 tons of ammonium nitrate fertilizer — enough to make up to a couple hundred roadside bombs, the Taliban’s most lethal weapon in what has been the deadliest year of the war, NATO announced Tuesday.

Separately, video footage emerged of insurgents brandishing what appears to be limited stocks of U.S. ammunition in a remote area of eastern Afghanistan where eight Americans died in a battle last month.

NATO officials hoped Sunday’s raid in the southern city of Kandahar would hurt Taliban militants, whose homemade bombs have become the biggest killer of U.S. and allied troops.

Acting on a tip, international forces and Afghan police discovered 1,000 100-pound bags of ammonium nitrate fertilizer and 5,000 parts for roadside bombs in a warehouse, the military said. After the initial find Sunday, an additional 4,000 100-bags of fertilizer were found in a nearby compound. The joint forces also made 15 arrests.

The seizure included enough fertilizer to make dozens to a couple of hundred roadside bombs, said John Pike, director of the military think tank Globalsecurity.org.

The insurgents have been successful manufacturing homemade bombs from materials such as fertilizer, which is easily available in agricultural areas of the south.
Experiment with KNO3 Detection - Atacama Desert, Chile

- User uploads signature of interest to spacecraft
- Example: Potassium Nitrate (KNO3, Niter, saltpeter) (USGS Spectral Library) used in Fertilizer and Explosives. Major Source Can be Found in Atacama Desert, Chile.
Experiment with KNO3 Detection - Atacama Desert, Chile conducted with Earth Observing 1

Product Generated Onboard: 7KB (EO-1)
Original Raw Data: 2.7GB

Potential KNO3

Detected Pixels (blue) as Overlay on Google Earth

In Less than 1 hour with a slow onboard CPU
Conclusion

- Decrease barrier to entry in SensorWeb domain by using simpler interfaces
- Easy development and usage will enable many societal benefits at lower budgets
- Disaster management is the perfect arena to test out these concepts because there is a large demand and need internationally
Backup Charts
Sample Application: Normanton, Australia, Flood SensorWeb
February/March 2009
Normanton, Queensland, Australian Floods February 2009
Data Simulation

• Prediction: TRMM-based Predictive Flood Potential Model
  - Robert Adler/University of Maryland – NASA/GSFC

• Survey: MODIS Flood Map
  - Robert Brakenridge/ Dartmouth Flood Observatory

• Details:
  • Earth Observing 1 Advanced Land Imager and Hyperion
    - NASA/GSFC – Image acquisition, flood map, automation
      -- Mandl, Frye, Cappelaere
  • Radarsat Flood Image
    - MDA/Canadian Space Agency – Image acquisition
    - Space Research Institute NASU-NSAU, Ukraine – Flood Map Production
      - Serhiy Skakun and Natalia Kussul
  • Landsat Water Mask
    - Space Research Institute NASU-NSAU, Ukraine – Water Mask
      - Serhiy Skakun and Natalia Kussul
  • Formosat Flood Image
    - Taiwan National Program Science Office – Image acquisition
      - National Cheng-Kung University – Data processing
      - Cheng-Chien Liu
Normanton Floods - Google Earth view from before floods (Quickbird image)
TRMM-based flood potential forecast for February 6, 2009

**Prediction**

Forecast valid at: 6 Feb 2009 0600 UTC

See TEKT REPORT of AFRICAN areas with forecasts of severe flooding near weather station locations

Flood Potential  Flooding  Severe

+24HR EXTRAPOLATION VT 6 FEB 2009 0600 UTC
Specific Water Level and Lat/Long Projected for Normanton Area

**FORECASTED** Flood Potential at 02/06/2009 0600Z

Forecast generated at 02/05/2009 0600Z

<table>
<thead>
<tr>
<th>COUNTRY</th>
<th>WATER LEVEL &amp; Latitude/Longitude</th>
<th>NEARBY LOCATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argentina</td>
<td>134mm -32.63 -60.88</td>
<td>33.96km from ROSARIO AIRPORT -32.92 -60.78</td>
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<td>Argentina</td>
<td>151mm -32.88 -61.13</td>
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<td>Australia</td>
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<td>107.79km from PALMerville QU-16 00 144.07</td>
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<td>Australia</td>
<td>129mm -14.88 129.38</td>
<td>84.91km from PORT KEATS AWS(AUT) NT-14.23 129.45</td>
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<td>Australia</td>
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<td>109.90km from PALMerville QU-16 00 144.07</td>
</tr>
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<td>Australia</td>
<td>131mm -16.88 141.13</td>
<td>20.25km from KOVAHYAMA QU-15 47 141.73</td>
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<td>Australia</td>
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<td>107.91km from KOVAHYAMA QU-15 47 141.73</td>
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<td>216mm -17.63 146.13</td>
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<td>170mm -5.13 120.38</td>
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<tr>
<td>Mozambique</td>
<td>168mm -25.89 32.63</td>
<td>7.07km from MAPUTO/MAVALENE -25.92 32.87</td>
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</tbody>
</table>

Use this lat/long to trigger other assets.
MODIS Flood Extent on Google Earth as KML File
February 18, 2009
**Survey**

Robert Brakenridge – Dartmouth Flood Observatory
MODIS Flood Extent on Google Earth as KML File
February 18, 2009
**Survey- Zoom**

Robert Brakenridge – Dartmouth Flood Observatory
MODIS Flood Extent on Google Earth as KML File February 18, 2009 **Survey- Closeup Normanton**

Robert Brakenridge – Dartmouth Flood Observatory
Article on Normanton Floods from the Northwest Star

Minister faces hazards in Gulf
TROY ROWLING
2/4/2009 9:05:00 AM
OVERFLOWING sewerage, crocodiles and mosquito-borne diseases were among the possible hazards Queensland Emergency Services Minister Neil Roberts faced when he arrived in the Gulf yesterday. Mr Roberts visited Karumba and Normanton to gauge the impact the floodwaters were having on the region.

And according to a statement released by Carpentaria Shire Council yesterday, there were quite a few issues making an impact on the isolated communities.

A spokesperson for Carpentaria Shire Council said the council was anticipating possible sewage overflows in the towns due to the inundation of pump stations.

The spokesperson also said there had been increased sightings of large crocodiles in the floodwaters surrounding Normanton and that Queensland Health had recommended the public avoid wading and playing in floodwaters due to mosquito-borne diseases.

However, despite the possible dangers, the Minister pressed on with his trip undeterred. “I’m here to be shown around the district and to talk to locals about the impact of the flooding,” Mr Roberts said. “I really need to take advice from local governments and emergency services personnel on the ground. So I’ll be waiting for their advice about what other measures need to be taken.”

The Carpentaria Shire Council spokesperson said another issue they planned to discuss with the minister was the upgrade of the Einasleigh and Gilbert crossings. They said this would enable road access for the essential re-supply of goods. The isolated communities were currently reliant on food drops via aircraft and a fortnightly barge service from Cairns to Karumba to supply food, fuel and essential items to residents in the area.

With the Norman River continuing to rise, the communities could be cut off for a further six weeks. Carpentaria Shire Council and Emergency Management Queensland met with local retailers and suppliers to discuss re-supply sustainability.
Retailers were encouraged to monitor stocks and liaise with the Council to ensure all residents had adequate food and other essential items.

A business advisor from the Department of Tourism, Regional Development and Industry was flown into Normanton at the weekend to help the businesses manage the effects of ongoing flooding on their bottom line.

His feet firmly on dry ground, Mr Roberts took time during his brief stopover in Mount Isa to thank local emergency services leaders for their hard work.

“I’ve received very good feedback from the Mayors in the local communities about the work and support the emergency service crews are doing,” he said.
Normanton Airport Ground View 2-15-09

Normanton Airport View 2  2-15-09

Radarsat-2 Water regions 14 Feb 2009)
Formosat-2 image 18 Feb 2009

Dr. Cheng-Chien Liu
Department of Earth Sciences
Earth Dynamic System Research Center
Institute of Satellite Informatics and Earth Environment
National Cheng-Kung University
Normanton Floods - February 18, 2009 Zoom 1

Main road to Hospital flooded

Hospital
EO-1 Image March 11, 2009
Radarsat/Landsat Flood Map

Radarsat Image 2-14-09 (red), 3 meter resolution
Landsat Image pre-flood 5-6-02 (blue), 30 meter resolution

Flood maps produced by the Space Research Institute NASU-NSAU, Ukraine

Red – flood waters
Blue – Existing waters
Find Flooded Streets
Normanton with Landsat 7 5-7-02, Radarsat 2 Flood Extent Overlay February 14, 2009 and February 17, 2009  3m resolution
Goal is to calibrate River Watch measurements which use AMSR-E to calculate river flows and thus provide early warning for flooding downstream