

Final Report: Sensorpedia Phase 3

SERRI Project: Sensorpedia

**Project Principal Investigators:
Bryan Gorman and David Resseguie**



This material is based upon work supported by the U.S. Department of Homeland Security under U.S. Department of Energy Interagency Agreement 43WT10301. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Department of Homeland Security.

SERRI Project: Sensorpedia

FINAL REPORT: SENSORPEDIA PHASE 3

Bryan Gorman and David Resseguie

Date Published:

January 2011

Prepared for
U.S. Department of Homeland Security
under U.S. Department of Energy Interagency Agreement 43WT10301

Prepared by
OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37831-6283
managed by
UT-BATTELLE, LLC
for the
U.S. DEPARTMENT OF ENERGY
under contract DE-AC05-00OR22725

CONTENTS

LIST OF FIGURES	v
ACRONYMS	vii
SOUTHEAST REGION RESEARCH INITIATIVE	ix
1. INTRODUCTION	1
2. BACKGROUND	1
3. SENSORPEDIA PHASE 3 RESULTS	2
3.1 Objectives	2
3.2 Status.....	2
4. BETA TEST EXAMPLES.....	2
4.1 PULSENNet.....	2
4.2 Haiti.....	3
4.3 High Flux Isotope Reactor	4
4.4 Tracking 2.0.....	6
4.5 Nuclear Nonproliferation.....	6
4.6 Resource Assurance	7
5. SENSORPEDIA IN THE MEDIA	9
6. CONCLUSION.....	10
7. REFERENCES.....	10

LIST OF FIGURES

1. PULSENet integration of OGC SWE with Sensorpedia services	3
2. HaitiServe iPhone application screenshots	4
3. HFIR information dashboard.....	5
4. HFIR QR Code mobile application.	5
5. Tracking 2.0 tracks an item through its entire life cycle using a virtual serial number	6
6. Sensorpedia provides a framework for a nuclear nonproliferation application	7
7. Resource assurance application showing energy infrastructure and population data for Nigeria	8
8. Resource assurance application showing energy related weather overlays	8
9. Resource assurance tool for mapping data to resilience metrics	9
10. Photo and caption from a <i>Knoxville News Sentinel</i> photo montage, August 15, 2009	9
11. David Resseguie (far right) joins (from left to right) Ryan Hahn from World Bank, Robin Hanson from Consensus Point, Shyam Sankar from Palantir Technologies, Emma Antunes from the National Aeronautics and Space Administration, and Don Burke from the Central Intelligence Agency in a panel discussion at the “Tap the Collective” event in Washington, D.C., September 2, 2009	10

ACRONYMS

HFIR	High Flux Isotope Reactor
HTML	HyperText Markup Language
KML	Keyhole Markup Language
OGC	Open Geospatial Consortium, Inc.
ORNL	Oak Ridge National Laboratory
PULSENet	Persistent Universal Layered Sensor Exploitation Network
QR	Quick Response (Code – a type of bar code developed in Japan)
RFID	radio-frequency identification
SERRI	Southeast Region Research Initiative
SWE	Sensor Web Enablement
TRL	Technology Readiness Level
URL	uniform/universal resource locator

SOUTHEAST REGION RESEARCH INITIATIVE

In 2006, the U.S. Department of Homeland Security commissioned UT-Battelle at the Oak Ridge National Laboratory (ORNL) to establish and manage a program to develop regional systems and solutions to address homeland security issues that can have national implications. The project, called the Southeast Region Research Initiative (SERRI), is intended to combine science and technology with validated operational approaches to address regionally unique requirements and suggest regional solutions with potential national implications. As a principal activity, SERRI will sponsor university research directed toward important homeland security problems of regional and national interest.

SERRI's regional approach capitalizes on the inherent power resident in the southeastern United States. The project partners, ORNL, the Y-12 National Security Complex, the Savannah River National Laboratory, and a host of regional research universities and industrial partners, are all tightly linked to the full spectrum of regional and national research universities and organizations, thus providing a gateway to cutting-edge science and technology unmatched by any other homeland security organization.

As part of its mission, SERRI supports technology transfer and implementation of innovations based upon SERRI-sponsored research to ensure research results are transitioned to useful products and services available to homeland security responders and practitioners.

For more information on SERRI, go to the SERRI Web site: www.serri.org.


1. INTRODUCTION

This report is a summary of the Oak Ridge National Laboratory's (ORNL's) Phase 3 development of Sensorpedia, a sensor information sharing platform. Sensorpedia is ORNL's "Wikipedia for Sensors." The overall goal of Sensorpedia is to enable global scale sensor information sharing for scientific research, national security and defense, public health and safety, emergency preparedness and response, and general community awareness and outreach.

2. BACKGROUND

Getting the right information to the right individual at the right time remains a key challenge for enterprises and organizations. With instrumented measurement and surveillance of enterprise infrastructures and the environment growing at a rapid pace, vast amounts of data are being collected. When paired with the evolving capabilities of predictive and analytical algorithms on powerful high-performance computing platforms, the growth and ubiquity of real-time sensor data offer enormous potential for knowledge discovery and enhanced decision support. However, while rich data exist from sensors that measure and detect changes in the environment and physical infrastructure, the problem of interoperability and information sharing for detection and response coordination within enterprises remains a grand challenge.

Since 2006, ORNL has been actively involved in research to formalize and implement the engineering principles and best practices behind emerging social media and social networking concepts, the "Internet of Things," to solve real-time data sharing problems for national security and defense, public health and safety, environmental and infrastructure awareness, and disaster preparedness and response. Sensorpedia, an ORNL program, is a practical application of several key social media principles. Dubbed the "Wikipedia for Sensors," Sensorpedia is currently in limited beta testing.



**Now this is how you do the
"Internet of Things"**

-FreakLabs via Twitter
Wireless Sensor Networks Blog

3. SENSORPEDIA PHASE 3 RESULTS

3.1 Objectives

Starting in 2008 and continuing to the present, the Southeast Region Research Initiative (SERRI) funded ORNL to develop a prototype Sensorpedia tool, which is currently in a limited release beta test version. Beta test participants include a broad cross section of interests: academic and scientific research, U.S. Department of Defense security, public safety and public health, and enterprise and international sensor standards development. The indexed sensors and sensor feeds (currently more than 5,000) also cover a range of observations from weather and environmental effects to space-borne and airborne remotely sensed imagery.

3.2 Status

Sensorpedia has been deployed as a beta prototype in multiple relevant environments, and the backend software is being used in a planned operational system. (The Sensorpedia technical application programming interface is available online:

<http://sites.google.com/site/sensorpedia/Home>.)

Although Sensorpedia is still currently in beta, not production, mode, various implementations of its core software (which is open source) were reused to address a number of specific enterprise requirements. These prototypes included published sensor network interoperability experiments, a mobile application for disaster response, a security and surveillance application for a nuclear reactor site, an innovative use of QR Codes for reading sensors and sensor documentation, a tracking application, an intelligence application, and a resource assurance application. Clearly, the Sensorpedia principle of loosely coupled interfaces to achieve interoperability between incompatible sensors can also be applied to other enterprise information sharing use cases.

4. BETA TEST EXAMPLES

The Sensorpedia architecture is designed to support a variety of sensor types and formats. Currently integrated sensors use GeoRSS, KML (Google's Keyhole Markup Language), HTML, plain text, and proprietary binary formats. Sensorpedia also interfaces easily with standards-based sensor systems, such as those defined by the Open Geospatial Consortium, Inc. (OGC). The OGC Sensor Web Enablement (SWE) standards initiative is one such framework of open standards for designing interoperable systems. The suite of standards within SWE includes both encodings for describing sensors and sensor observations and standard interface definitions for Web services.

The following sections describe some representative Sensorpedia applications from the beta test.

4.1 PULSENet

Northrop Grumman's PULSENet (Persistent Universal Layered Sensor Exploitation Network) is an OGC SWE-based architecture. "The objective of PULSENet is to provide a

standards-based framework for the discovery, access, use, and control of heterogeneous sensors, their metadata, and their observation data” (Resseguie and Fairgrieve, 2010). PULSENet is implemented with “a combination of open-source SWE code, commercial off-the-shelf products, and custom development to construct a framework that provides an adaptive and flexible environment for integrating sensors” (Resseguie and Fairgrieve, 2010). Northrop Grumman has applied PULSENet to “a range of applications spanning the environmental, defense, and intelligence domains” (Resseguie and Fairgrieve, 2010). During Phase 3, ORNL and Northrop Grumman developed a tool for interfacing SWE systems with Sensorpedia (Resseguie and Fairgrieve, 2010). Figure 1 illustrates this tool.

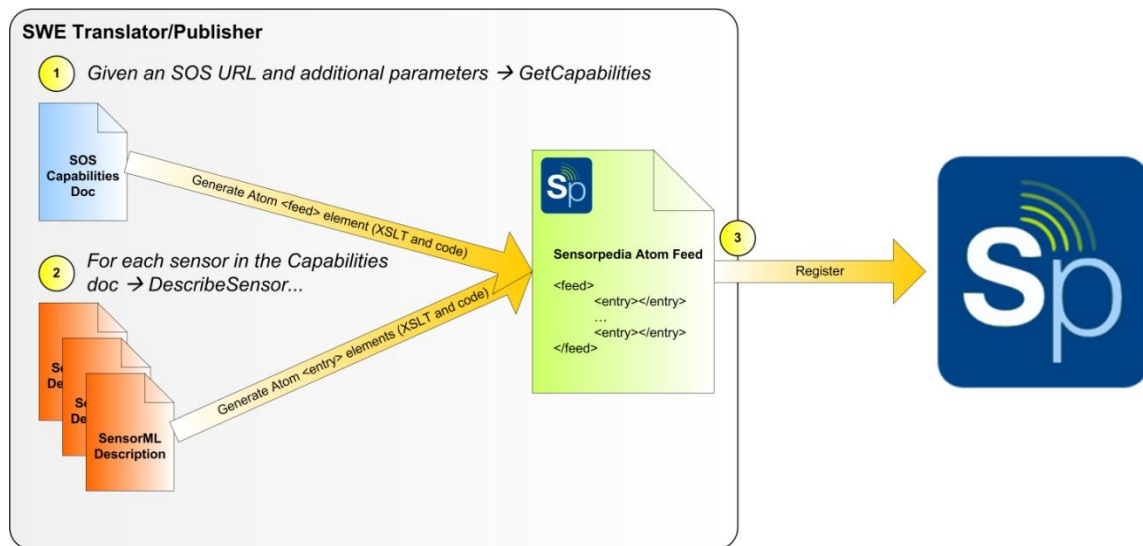


Fig. 1. PULSENet integration of OGC SWE with Sensorpedia services.

4.2 Haiti

Following the earthquake on January 12, 2010, in Haiti, many volunteer organizations began to organize relief efforts. A key issue faced by relief organizations was the coordination of emerging needs and available resources. In conjunction with the nonprofit HaitiServe organization, an iPhone application was developed to enable the cataloging of needs and resources by volunteers (Fig. 2). By mapping volunteer observations to the sensor observation model, the application was able to use the Sensorpedia backend services to store and service requests from the HaitiServe application.

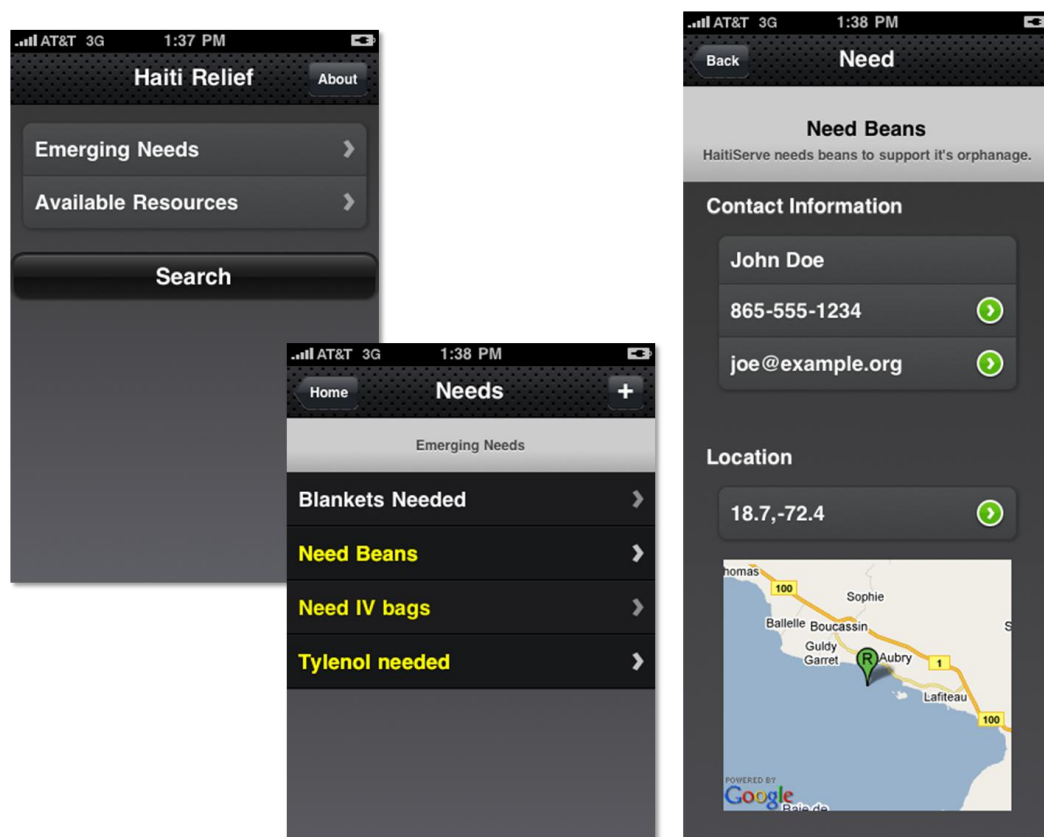


Fig. 2. HaitiServe iPhone application screenshots.

4.3 High Flux Isotope Reactor

Although Sensorpedia.com primarily supports open, public data, the software may also be installed behind an enterprise firewall for handling sensitive and protected information. This approach was used in the development of an emergency response application for the ORNL High Flux Isotope Reactor (HFIR). This application serves as an information dashboard to assist operators in prioritizing their response procedures based on alarms from within the reactor and radiation sensors placed external to the facility (Fig. 3). Sensorpedia provided the capability to interface the data without requiring modifications to existing certified systems within the reactor. Having the data available via the Sensorpedia services also enables the development of mobile applications for accessing real-time sensor readings relevant to currently active response procedures. A prototype application was developed using QR Codes that may be scanned by a mobile phone to retrieve data required to complete a specific procedure (Fig. 4).

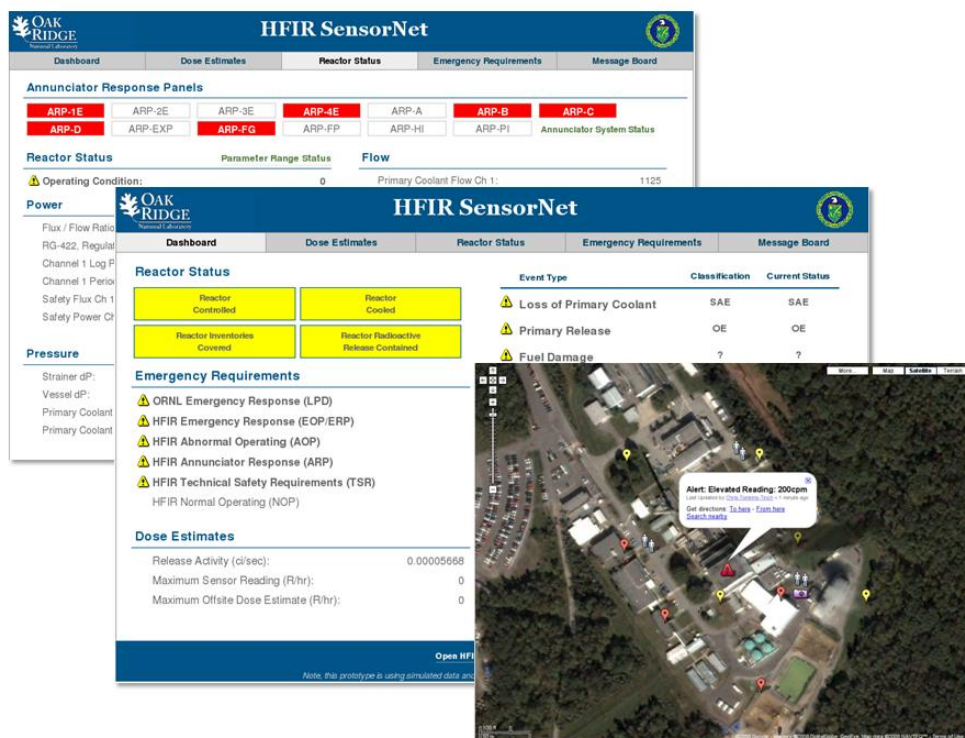
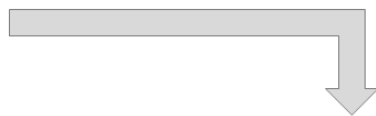


Fig. 3. HFIR information dashboard.



<http://sensorpedia.com/hfir/proc/ARP-1E-21>

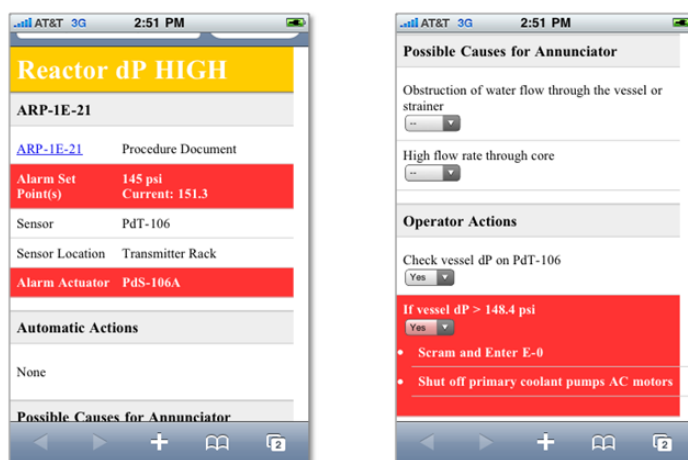


Fig. 4. HFIR QR Code mobile application.

4.4 Tracking 2.0

The Sensorpedia model is also applicable to the tracking of packages, containers, vehicles, and other items of interest through mapping RFID (radio-frequency identification) tags, barcodes, and other existing tracking systems to the sensor observation model. Tracking 2.0, as the system is known, assigns a unique URL to an item being tracked that serves as a virtual serial number (Fig. 5). This URL points to a Sensorpedia feed containing metadata about the item describing its location, condition, and other relevant information. The metadata are captured through the use of tags, enabling a simplified search across systems. Tracking 2.0 is agnostic to the specific tracking technology used and works with any technology that provides an identifier that can be resolved to a URL (such as QR Codes and RFID tags).



Fig. 5. Tracking 2.0 tracks an item through its entire life cycle using a virtual serial number.

4.5 Nuclear Nonproliferation

The Sensorpedia architecture was used in the development of two nuclear nonproliferation applications. In one system, intelligence cables are mapped to the sensor observation model to support an export control case processing application. In the second system, Sensorpedia provides a framework for collecting information about possible threats of nuclear material smuggling including web cameras, ship tracking, and other sensor data (Fig. 6).

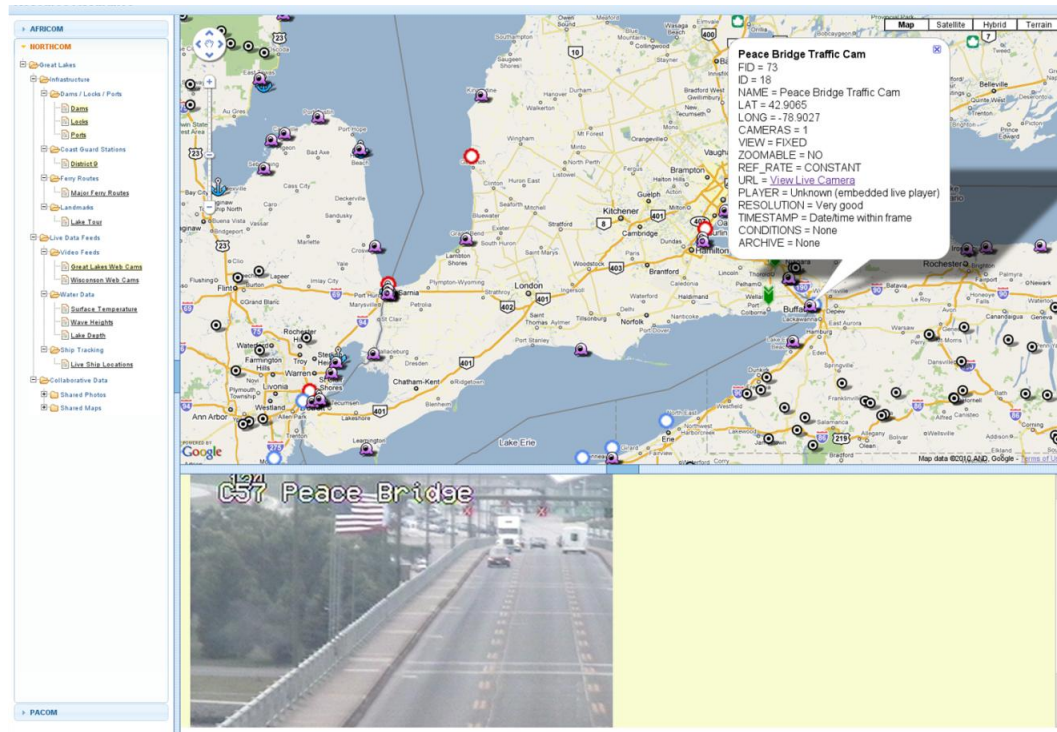


Fig. 6. Sensorpedia provides a framework for a nuclear nonproliferation application.

4.6 Resource Assurance

The Sensorpedia architecture was demonstrated at a conference attended by various members of the U.S. Unified Combatant Commands and consequently was used in the development of a framework to provide the capability to ensure the availability of critical resources in key areas of interest (Figs. 7 and 8). In yet another prototype, the application was used to inform decision making in a mock water shortage scenario that resulted in mass refugee movement. Other prototypes captured information regarding energy use and availability in Guam and Hawaii. Finally, an application is currently being developed using the Sensorpedia framework for mapping data sets to resilience metrics for U.S. Pacific Command areas of interest (Fig. 9).

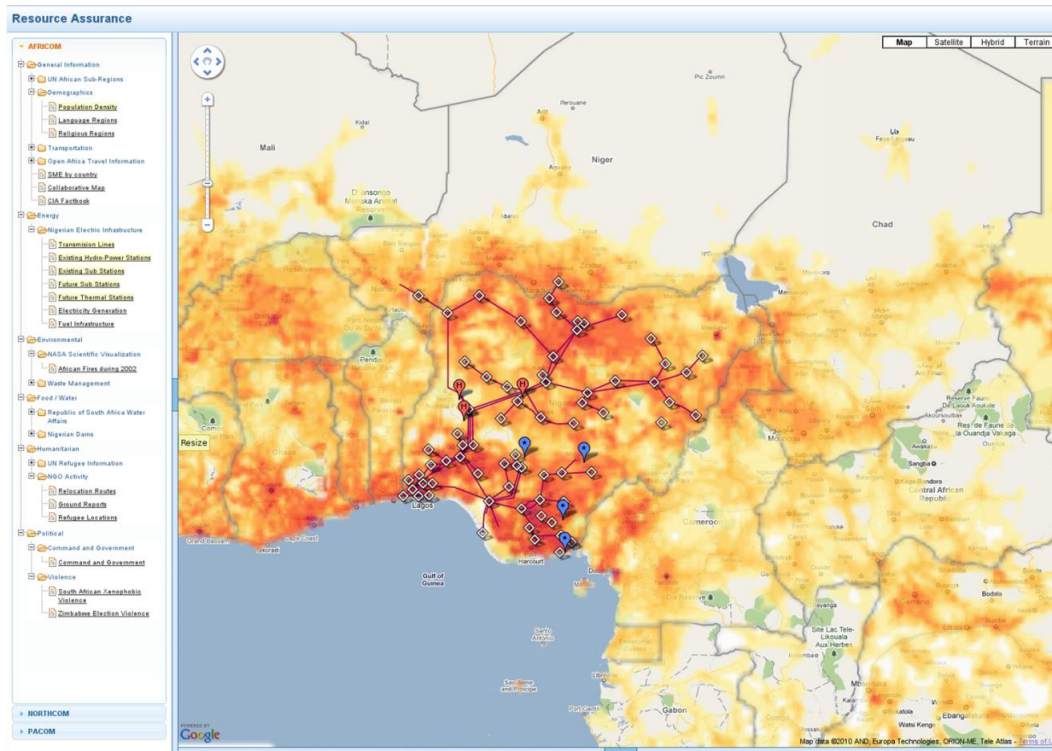


Fig. 7. Resource assurance application showing energy infrastructure and population data for Nigeria.

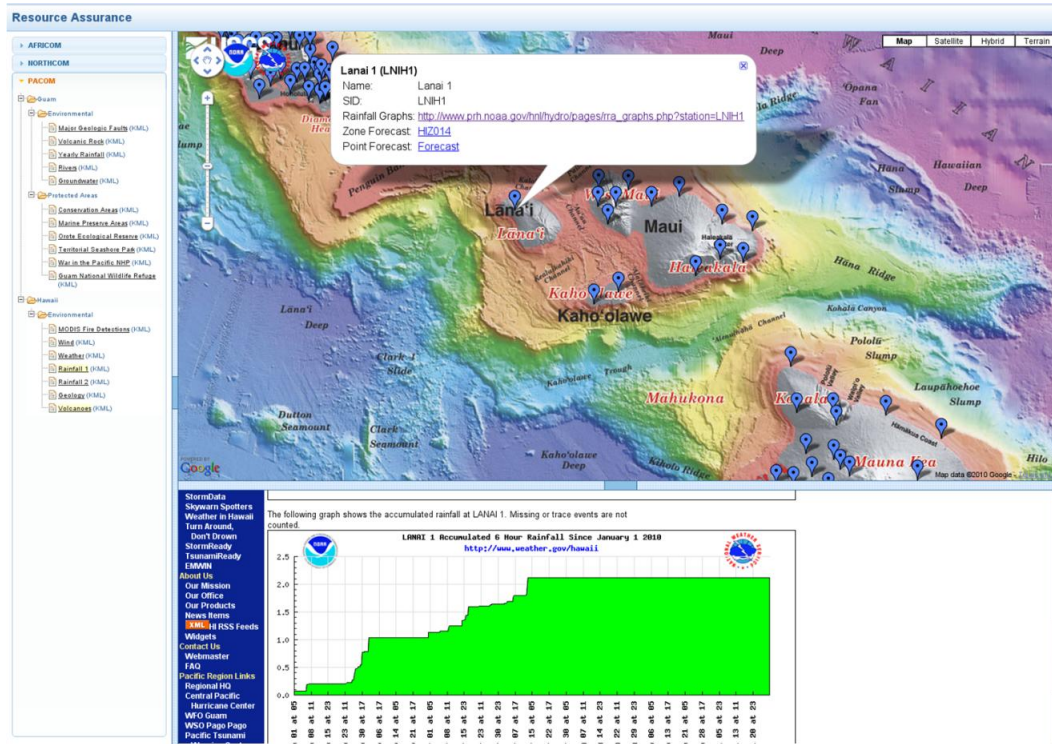


Fig. 8. Resource assurance application showing energy related weather overlays.

Resource Assurance: Knowledge Tagging Tool

South Asia » Nepal » Kathmandu

Matching Data Sets

Humanitarian Assistance

H1. Has a post event hazards assessment been made?

H2. Do secure staging areas exist for aid organizations to operate from?

H3. Do local law enforcement resources exist to protect aid organizations?

H4. Do local law enforcement resources exist to protect aid storage and distribution sites?

H5. What kind of food makes up a normal diet?

H6. Do local food sources exist to support refugees and/or internally displaced persons (IDPs)?

Public Health Systems

Infrastructure

Disaster Preparedness

Education

Communication & Information

Research & Innovation

Economy

Sustainable Development

Resource Management

Social Cohesion

Leadership

Institutional Capacity

Rule of Law

Security

Protection of Rights

Assessment

Nepal Demographics
2010-11-22

Nepal's population has grown from 9 million people in 1950 to 29 million in 2010. At the time of the 1981 census, the total population of Nepal was 15 million, the average family was made up of 5.8 persons. The Nepalese are descendants of three major migrations from India, Tibet, and North Burma and Yunnan via Assam. Even though Indo-Nepalese migrants were latecomers to Nepal relative to the migrants from the north, they have come to dominate the country not only numerically, but also socially, politically, and economically. Nepal is a multilingual society. These data are largely derived from Nepal's 2001 census results published in the Nepal Population Report 2002
<http://www.csb.gov.np/publications/2002/Nepal%20Population%20Report%202002.pdf>

Global Hunger Index 2010
2010-10-01

Nepal was ranked 29th worst of 84 ranked countries (those with GHI > 5.0) on the Global Hunger Index in 2010, between Tanzania and Kenya. Nepal's current score of 20.6 is slightly worse than in 2009 (19.8) but better than its score of 27.5 in 1990.
<http://www.gridh.net/countries/2010/2010-global-hunger-index-2010.pdf>

Economy of Nepal (Wikipedia)
2010-09-13

Nepal has used a series of five-year plans in an attempt to make progress in economic development. It completed its ninth economic development plan in 2002; its currency has been made convertible, and 17 state enterprises have been privatized. Foreign aid accounts for more than half of the development budget. Government priorities over the years have been the development of transportation and communication facilities, agriculture, and industry. Since 1975, improved government administration and rural development efforts have been emphasized.
http://en.wikipedia.org/wiki/Economy_of_Nepal

ORNL LandScan 2010
2010-08-29

ORNL provides federal, state and international organizations with an annually updated gridded population database, called LandScan, for estimating ambient population. LandScan is a raster image, or grid, of population counts, which provides human population estimates every 30 x 30 arc seconds, which translates roughly to population estimates for 1 kilometer square windows or grid cells at the equator, with cell width decreasing at higher latitudes
<http://www.ornl.gov/landscan/>

Filter

Keyword(s)

Determine Area

Tag(s)

Apply

Not enough data? Add some more!
Register a Data Set

Need help getting started?
Take a Tour

demographics
ethnicity language
literacy population
religion

food ghi health
mortality
undernourishment

agriculture business
communications
exports gdp
hydroelectricity
textile tourism
trade transportation

demographics
density ornl
population size






Fig. 9. Resource assurance tool for mapping data to resilience metrics.

5. SENSORPEDIA IN THE MEDIA

ORNL has been very successful in getting the Sensorpedia “brand” into the Web 2.0 and Gov 2.0 discussion, presenting its SERRI-sponsored development on both the local stage (Figure 10) and the national stage (Figure 11).



“David Resseguie, a systems analyst at Oak Ridge National Laboratory, is using social networking frameworks to share information from sensing devices like the Sun SPOTs shown here at his offices at ORNL.”

—Knoxville News Sentinel

Fig. 10. Photo and caption from a *Knoxville News Sentinel* photo montage, August 15, 2009.



Fig. 11. David Resseguie (far right) joins (from left to right) Ryan Hahn from World Bank, Robin Hanson from Consensus Point, Shyam Sankar from Palantir Technologies, Emma Antunes from the National Aeronautics and Space Administration, and Don Burke from the Central Intelligence Agency in a panel discussion at the “Tap the Collective” event in Washington, D.C., September 2, 2009.

6. CONCLUSION

During Phase 3 of the Sensorpedia project, the Sensorpedia Web 2.0 core was used in a number of “proof of principle” applications where it was demonstrated that Sensorpedia could simplify the interoperability of legacy enterprise systems that were not developed to interface with other enterprise systems while preserving the integrity, security, authenticity, and provenance of sensor information. As a decision support tool, Sensorpedia can be combined with enterprise collaboration solutions to link work groups that need to share information for a common operating picture – both spatially and temporally. The Sensorpedia core, implemented into other systems, will provide enterprises with easy access to legacy information and will also improve interoperability among organizations that need to share sensor data quickly and effectively.

7. REFERENCES

Resseguie, D., and S. Fairgrieve, “Unifying isolated sensor systems using Web 2.0 and open standards,” *Sensors Magazine* (online), May 1, 2010.



Southeast Region Research Initiative

National Security Directorate

P.O. Box 6242

Oak Ridge National Laboratory

Oak Ridge, TN 37831-6252

www.serri.org

