

24 - 26 February, 2012

Rome, Italy

SENSORNETS 2012

1ST INTERNATIONAL CONFERENCE ON SENSOR NETWORKS



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*Embedded & Interconnected Devices:
Converting the Physical World into an Information System.*

Paul Lencioni

Topics



- Mapping Policy Issues to Science & Technology Needs
- Sensing, environmental monitoring, and “virtual observatories”: new capabilities and challenges
- Funding programs and “National Broadband Plan”
- Case Studies: funded research
- Dashboards – web application examples
- Distributed Processing & Self-Powered Networks
- Conclusions

Industry backgrounder

- Engineering studies University of Illinois, University of Southern California



- Telecommunications background: Hughes Space Systems, (Boeing), Loral, Cisco Systems, ZTE Corporation



- Consulting: MTI, Crimson, NetLink



- Collaboration with Academia: MIT, Illinois, University of Montana, Stanford



- Areas of particular interest: wireless and heterogeneous networks, satellite and remote area broadband, new business models and commercialization

Endless Applications for Sensor Networks



Predictive maintenance

Energy Saving



Healthcare



Defense



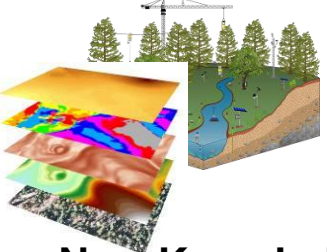
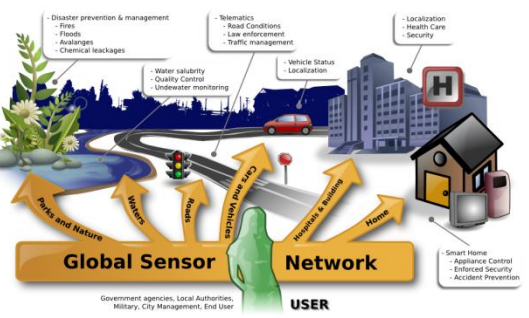
Improve Productivity



Intelligent Building



Agricultural



New Knowledge

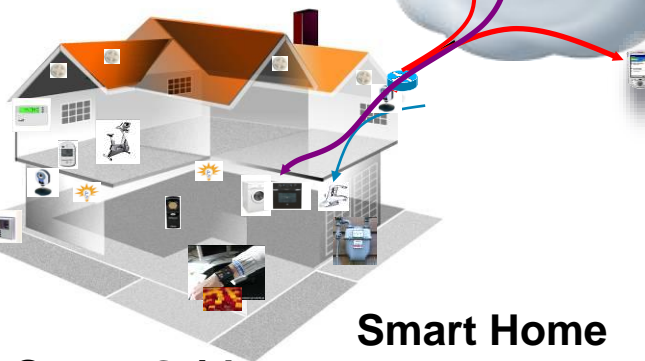
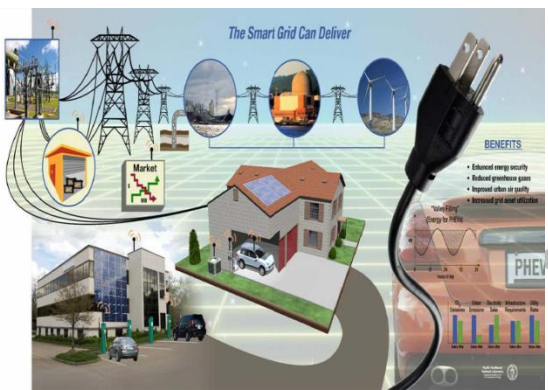
Smart Cities



High-Confidence Transport and assets tracking



Industrial Automation



Smart Grid

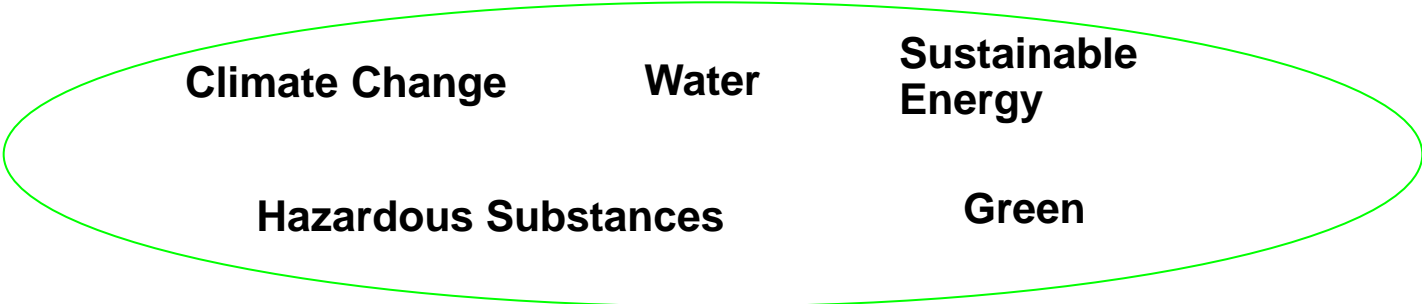
Smart Home

Key Global Policy Issues

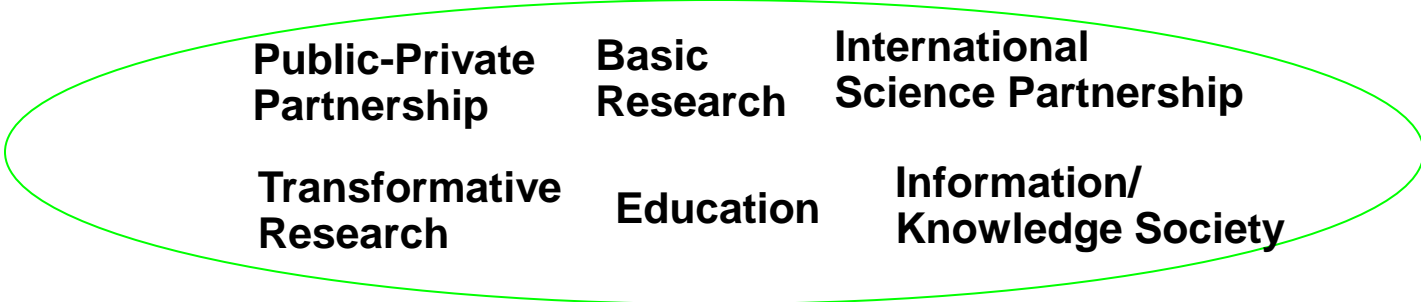
General



Environmental Challenges



Global R&D



Areas for R&D and Education

Include:

- Climate system and all that is required to measure, model and understand it
- Renewable energy sources and storage
- Alternative vehicles and transportation
- Carbon cycle and sequestration
- Advanced nuclear power
- Electric grid overhaul
- ICTs – instrumentation, computation, networking, energy management, vehicular traffic management, etc. (conservation/efficiency)
- Economic modeling
- Behavioral sciences

Near-term Needs

Include developing mechanisms for:

- conserving energy;
- encouraging energy efficiency; and
- identifying, developing, and deploying sustainable existing / emerging energy technologies.

Longer-term Needs

- Understanding and applying the basic science related to climate and the carbon cycle;
- Accelerating innovation in sustainable energy technologies and facilitating their transfer into the marketplace;
- Exploring the potential of new materials for better energy storage and conversion from one form to another; and
- Educating and training a workforce to operate in the new energy economy.

Internet Protocol for Smart Objects Alliance (2008)

- Cisco, Arch Rock, Silver Spring Networks, Sun Microsystems, Dust Networks, Duke Energy...
- Sensor / Control Networks are everywhere... with a vast scope of applications
- Working groups, trials, interoperability testing, architecture design, Use Cases, tutorials, etc.
- **"Interconnecting Smart Object with IP: The Next Internet"**



Wearable Devices: The Next “Smart” Platform

■ <http://www.vlab.org/article.html?aid=435>



Leveraging the SmartPhone ecosystem and Moore’s Law, entrepreneurs are launching a new class of small wearable devices. These general purpose compute platform devices are about to disrupt the world of consumer electronics and embedded devices, because they provide modern UIs and open Software development environments.

Start-ups, and giant global companies like Sony Ericsson and Motorola target the wrist as the beachhead, to launch these new platforms.

- Will entrepreneurs re-invent Watches, Consumer Electronics, Sporting gear, Medical equipment?
- Will the devices work as clients to Smartphone or the Cloud or both?
- Will entrepreneurs build Apps and services for Wearables, as they did for Smartphone and Tablets?
- How will start-ups team with enterprises to create Wearable Platforms?

American Recovery and Reinvestment Act of 2009 (ARRA)

Basic sectors:

- **Healthcare**
- **Education**
- **Infrastructure**
- **Government facilities**
- **Energy**
- **Housing**
- **Scientific Research**

U.S. is ranked 12th globally in broadband penetration; 15th in average broadband speed.

Excerpt from President Obama's Signing Statement:

"I hope that this investment will ignite our imagination once more, spurring new discoveries and breakthroughs that will make our economy stronger, our nation more secure, and our planet safer for our children"



Touted as the first dramatic new investment in the future since the creation of the interstate highway system a half century ago.

Breakout – ARRA investment



❖ ***Clean, Efficient, American Energy:***

Smart Grid/Advanced Battery Technology, Energy Efficiency, includes tax incentives for renewable energy

❖ ***Transforming our Economy with Science and Technology:***

Extending Broadband Services (\$7 Billion), Investing in Scientific Research (~\$15 Billion), via agencies such as NIH, NSF, NASA, DARPA, DOE, DOT.

❖ ***Modernizing Roads, Bridges, Transit and Waterways:***

Prioritizing Clean Water/Flood Control/Environmental Restoration, Provides \$18 billion for clean water, flood control, and environmental restoration investments, modernizing public infrastructure

“For every dollar invested in broadband, the economy sees a ten-fold return on that investment.”

Planetary Skin:

“online global nervous system”

“PSI is dedicated to open standards and open innovation approaches where appropriate and feasible to provide a platform as a service (PaaS) environment for advancing applied decision research and rapid prototyping.”



<http://www.planetaryskin.org>

Planetary Skin

Connected Decision Spaces approach

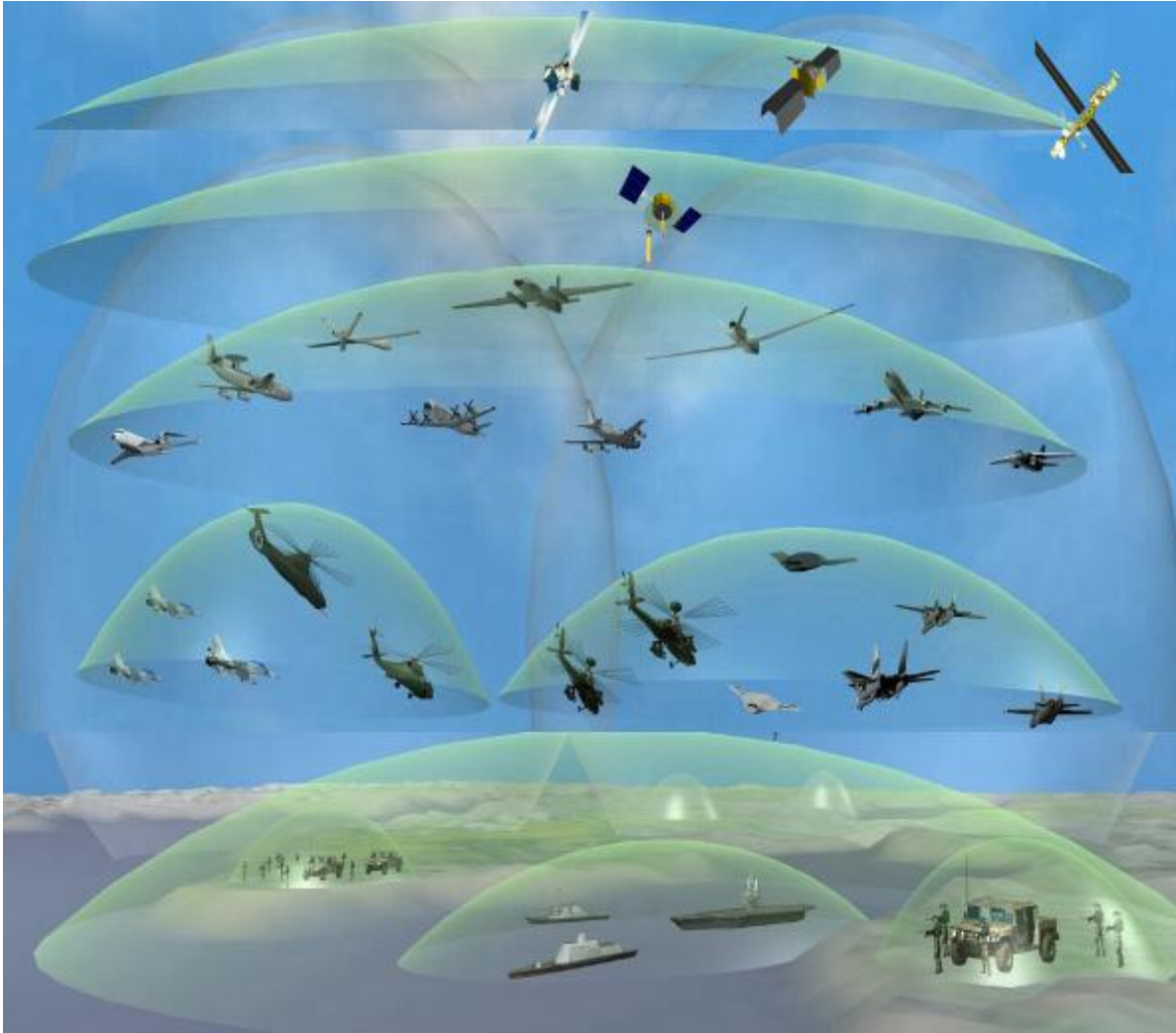
- **Connected Decision Spaces (CDS) create trusted collaborative networks**
- **CDS leverages Web 2.0 technologies integrated and blended into a nervous system for the intelligent management of infrastructures across human, machine, sensor, and simulated environments**
- **CDS is provisioned by a common fabric connecting all nodes on the network - data, machines, systems, objects, and people**
- **CDS embraces the network as the platform.**
- **Enables communication, collaboration, and data flows (CCD) where collaborative communications, distributed intelligence, and immersive workspaces are central to the way we make decisions**

**All about the “Service”
provisioned to any interface/node**



CDS is not always called out for each project, but the principles and framework are being applied

Telecommunications Trends In Government



- **Every platform has sensors**
- **Increasingly these sensors include video**
- **Common Data Link (CDL) & Tactical CDL (TCDL) will provide connectivity at rates up to 274Mbps over satellite**
- **This data will be broadcast and also stored for later detailed analysis**
- **Video and Sensor Data will drive the next iteration of Defense networks**

Nett Warrior

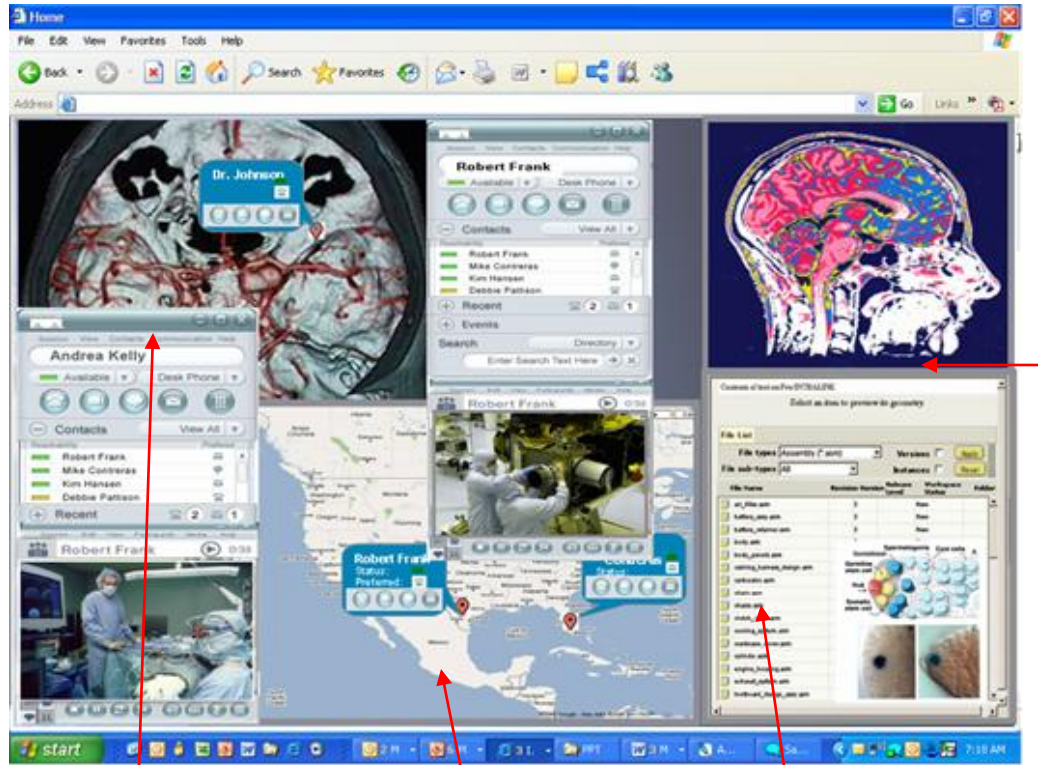


A United States Army program to equip soldiers with wearable computer system.

- The Army envisions a “Smartphone or “like” device that can provide “commercial-based, integrated computer, display and data-entry capability for dismounted use in either standalone or networked configuration.”
- “To provide the Soldier with enhanced mission planning, monitoring, communication and situational awareness.”
- Moving toward an Android platform?

- “Integrated camera, GPS, compass, accelerometers”
- “Sunlight-readable”
- “Ability to dim the screen for night operations.”

Health monitoring portals & related applications



Source: Cisco IBSG

Research

Rich and immersive data access and utilization through mash ups of experts, sensors, video, fused data, and other content

Click to collaborative and interact with vital team members and global experts to improve precision of vital activities, overcoming complications, and ensuring success.

Integrated decision support environment across, community, partners, patients, and suppliers that allows the problem resolution centric social network to operate on the same page of information and expert views

Integration of Unified Communications

VoIP, IM, radios, mobile, etc

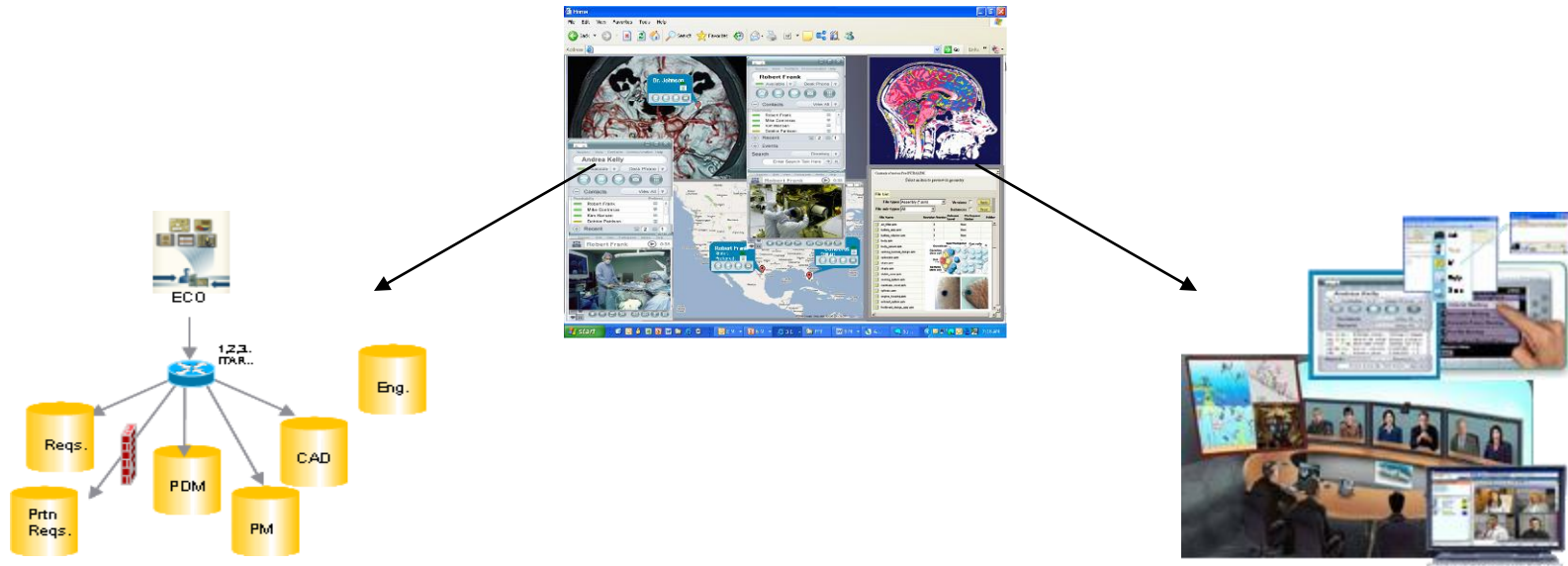
Integration of Collaboration

TelePresence, Web, Video, Voice

Integration of Content Aggregation

XML, Video, Sensors, RFID

“Now” Available Services



DISTRIBUTED INTELLIGENCE

- Fusion of disparate data into open standard XML – linking application versions and silo applications (PDM, Requirements, CAD, SCM, ERP, MRP, etc)
- Compliance Engine – distributed network mining services to automate packet and message level policy based decisions either for compliance or notification (ITAR, ethics, priority, 3rd party notification, etc)
- Event Management – distributed event monitoring and notification based on schemas distributed throughout the network to take action based on policy and instructions
- Wide Area Application Services – Content management, distribution, and application acceleration services for inefficient applications and for Web 2.0 rich media management

COLLABORATIVE COMMUNICATIONS

- Click-to-Communication across any environment whether voice, video, and/or data. Also across any means VoIP, PSTN, Mobile, Radio, Text, and Email. Integrated into processes and applications
- Click-to-Collaborate multi-channel collaboration via the web, text, voice, and video tightly integrated into the flow of an process or application
- TelePresence – High definition multi-point collaboration for program reviews, engineering collaboration, customer engagements, and supplier/partner management.
- Archival of Collaboration – Recordings of key collaboration moments for archival purposes, whether education, investigation, and/or compliance

Collaborative Research Centers



**Live Feeds and
Historic Analysis**

Modeling & Simulation

**Aggregating &
Fusing System
Views**

**Advanced
Communication &
Collaboration**



Brain-Computer Interfaces



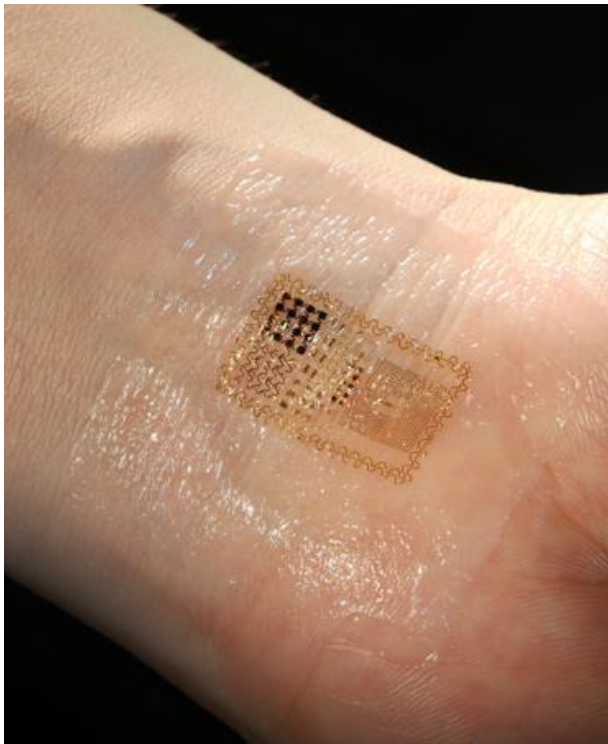
Smarter skin with diagnostic tattoo:

The skin-like wearable electronic interface developed at the University of Illinois opens up possibilities in the field of brain-computer interfaces well beyond biomedical applications.

A miniature diagnostic device with the mechanical properties of skin was developed by engineers at the University of Illinois. It can be mounted directly to the wrist or anywhere on the human body for EMG and other measurements.

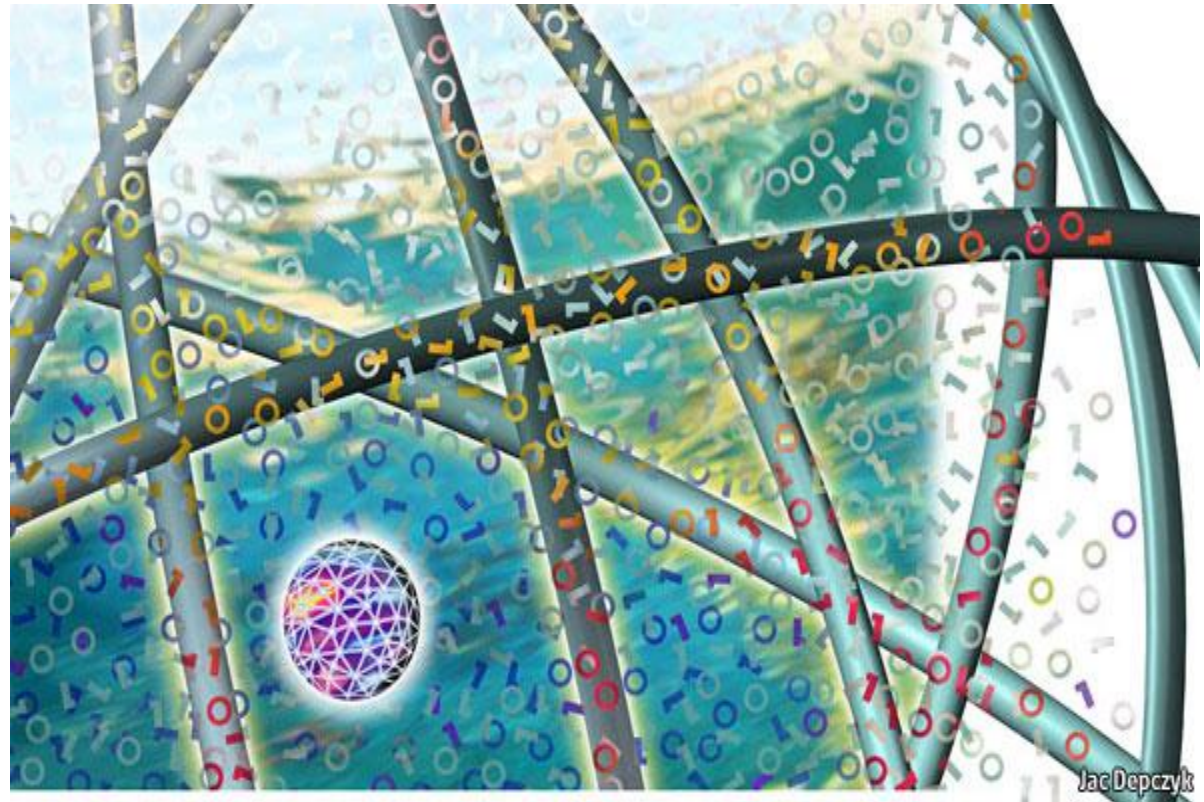
The circuit almost becomes part of the skin as it bends, wrinkles, and stretches.

Components in the circuit include sensors, LEDs, transistors, radio frequency capacitors, wireless antennas, and conductive coils and solar cells.



Data Everywhere

- The era of ‘big data’ is only beginning
- Sensors and newly ‘connected devices’
- Visualization and real-time monitoring
- How to manage the ‘data deluge’??



“Information has gone from scarce to superabundant. That brings huge new benefits—but also big headaches.”

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Environmental monitoring, sensor-to-web applications and “*virtual observatories*” portals

HUMANITARIAN TRENDS

RISK AND VULNERABILITY MAPPING



World HE

- HOME
- MAPS
- THINKING TOOL
- RESOURCES
- ABOUT US
- PARTNERS
- CONTACT

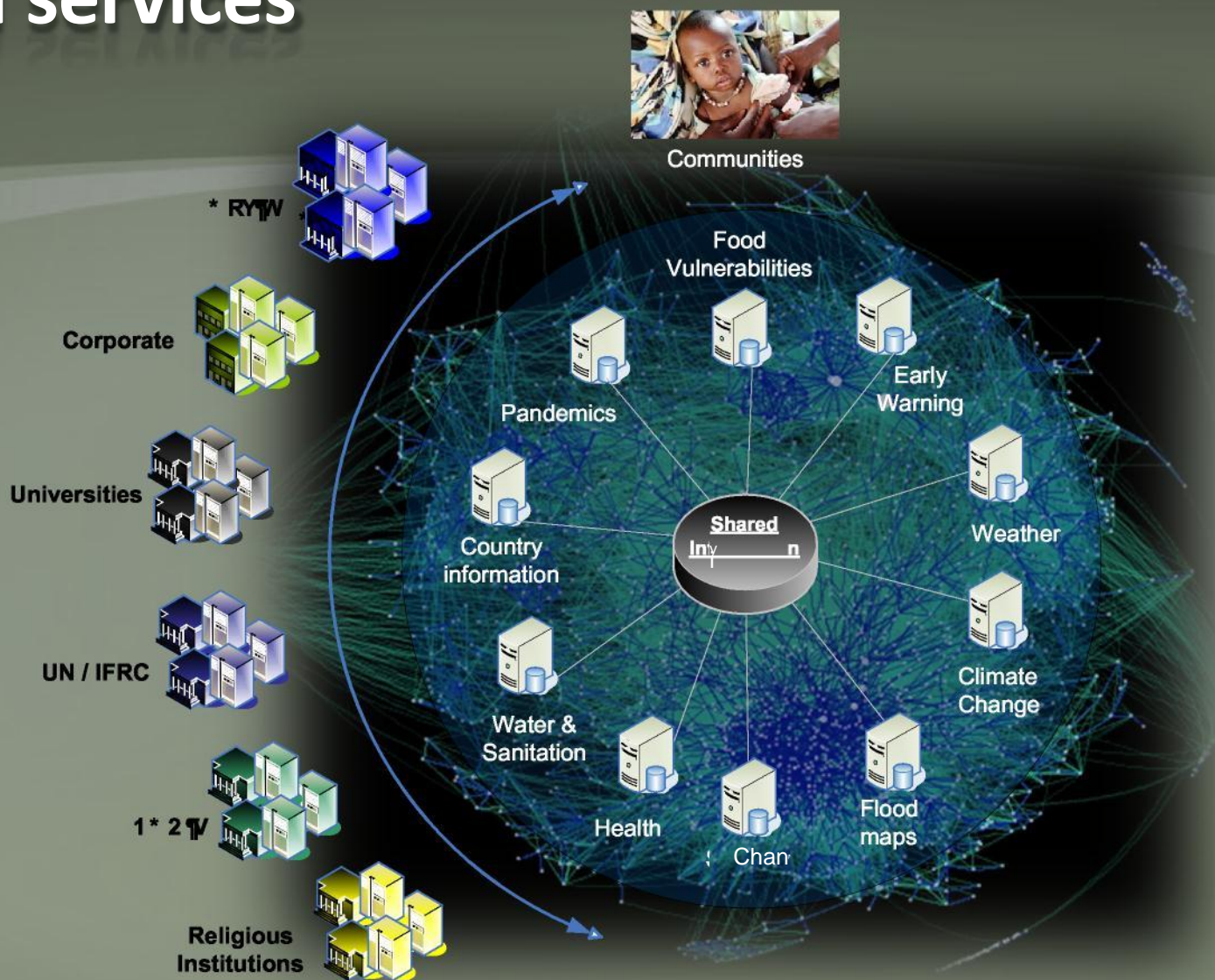
Thinking Tool



Global Indicators for Virus Outbreak: Pandemics, Airport Hubs, SARS Outbreak Example, Population Density, Infrastructure Resources / Government Response

Disaster Management Operational Dimensions

Cloud services





Cloud services



Dynamic information

By developing a mash-up of humanitarian information. Impending risks and immediate alerts can be distributed to the Public, Governments, Development & Relief agencies, and the Private sector through existing telecommunications infrastructure.



Think tanks

By making humanitarian information available through a managed service. Think tanks outside the Humanitarian industry can assist in trend, cause and effect, impact and ROI analysis from any location in the world.



Social Data Collection / mining

Social networking solutions can be linked or developed to enhance research data through humanitarian web 2.0 communities. TeleCentres/computer centres are being implemented across the developing world at a rapid pace developing the foundation for data mining opportunities.



Data Collection

The recent growth in GIS (Geographical Information System) technology is only beginning to impact the humanitarian sector. While paper-based surveys and assessments have been a part of development and relief programmes for many years, Agencies have started the transition to more accurate and effective electronic solutions.

New Vision for Relief Efforts

Mobile GIS for Emergency Planning and Humanitarian Aid

WorldVision has implemented a mobile GIS system to help emergency responders in the field. The system is designed to be used by field staff and is easy to use. It allows for the collection and analysis of data in the field, which can be used to plan and coordinate relief efforts. The system is also used for monitoring and reporting on relief efforts.

Disaster planning and preparedness are key elements of a successful disaster response. Mobile GIS can help organizations to plan and prepare for disasters by providing them with the tools and information they need to make informed decisions. Mobile GIS can also be used to monitor and report on disaster relief efforts, which can help organizations to improve their response and provide better support to those affected by disasters.

Mobile GIS for Emergency Planning and Humanitarian Aid

Global Centre for Humanitarian Services

WVI World Vision **GCHS**



Cloud services

Microsoft Office 12

Microsoft Office Humanitarian Business Suite

* All Logos are sole property of The Microsoft Corporation



Portfolio of services



Project Design, Monitor & Evaluation:

The goal is to produce a service for data capture and storage based on standard sets of information that can be quantified to ensure development programmes are meeting the needs of beneficiaries and evaluated for effectiveness.



Rapid Assessment:

In order to rapidly assess relief programme requirements, the humanitarian sector requires a solution to quickly collect and transfer information from the field to a central reporting system.



Portfolio of services



Human Resources Information System:

In large-scale relief operation, Agencies will rapidly hire between 500 and 1000 new employees. Current systems are not flexible making for significant time delays in placing staff in the field.



Security Tracking:

To ensure the safety of relief staff, agencies are implementing field security tracking systems. By sharing security incidents agencies will be able to track dangerous routes, avoid conflict zones and ensure efficient movement of relief goods and staff.



Portfolio of services



Fleet Management:

Developing a service to track movement, lease agreements, fuel consumption, maintenance records, high risk routes (car jacking) and insurance information.



Customer Services:

To ensure agencies are meeting the needs of beneficiaries, a system is required to track predefined key performance indicators. This system will be web-based and available in
—Community Centres // —Telecentres // or through mobile kiosk systems.



Portfolio of services



Shelter Management::

In international law it is the responsibility of the government concerned to provide assistance and protection for the IDPs in their country. However, as many of the displaced are a result of civil conflict and violence or where the authority of the central state is in doubt, there is no local authority willing to provide assistance and protection.



Missing person / Trace N' Track register:

Providing the Humanitarian industry with a standard missing person registry will allow agencies to work together to reunite families.



Portfolio of services



Global Supply Chain:

An integrated service that includes a Warehouse module, Online store, Procurement module and Trace N' Track would greatly assist in the delivery of relevant goods quickly and efficiently.



Connectivity:

Connectivity remains the —Achilles heall of the Humanitarian industry. Development of a global architecture for voice and data communications following industry standards will enable agencies to share bandwidth, develop shared service centres and eventually enable a global Humanitarian ISP.

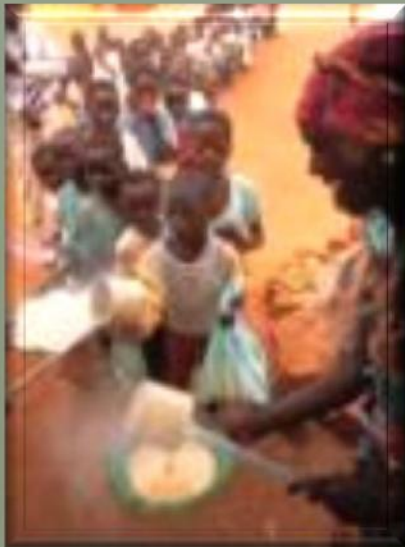


Portfolio of services



Education:

Professional degree and certification programmes are required to ensure consistency and quality of field practitioners.



Food Distribution:

As food and fuel prices continue to rise, poor households that were already struggling to afford the basics are being pushed deeper into poverty, while many newly vulnerable groups are emerging - particularly in urban areas. More than 800 million people in developing countries experience hunger daily.



Portfolio of services



Refugee tracking system:

Current global migration patterns are particularly complex, involving not just refugees, but also millions of economic migrants seeking a better way of life.

Climate Change:

Climate Change adaptation - Adaptation involves helping families, communities, regions, and nations get ready for what is coming from Climate Change. (disaster risk reduction / community resilience)

Climate change mitigation . Mitigation will support those activities which reduce either emissions or atmospheric concentrations of Greenhouse Gas (GHG). (including Land Use issues like deforestation, as well as burning less fossil fuel.)





NetHope Connectivity Explorer



Global Centre for
Humanitarian Services

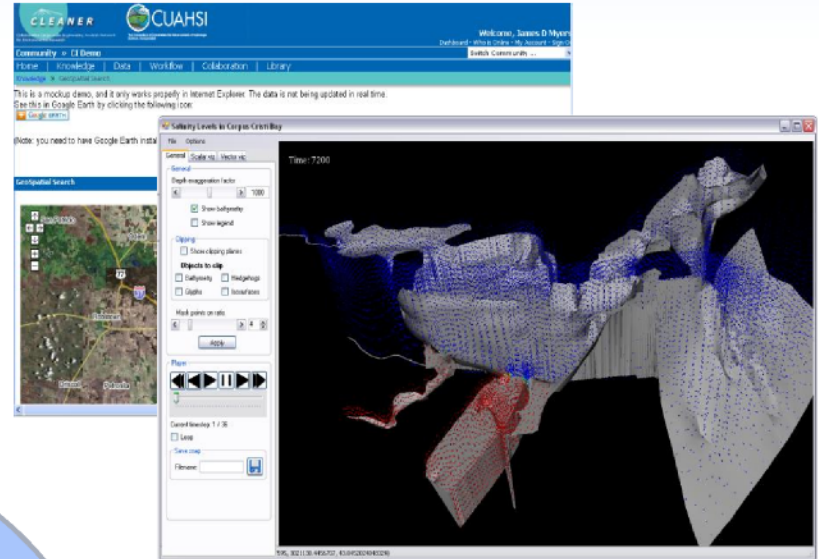
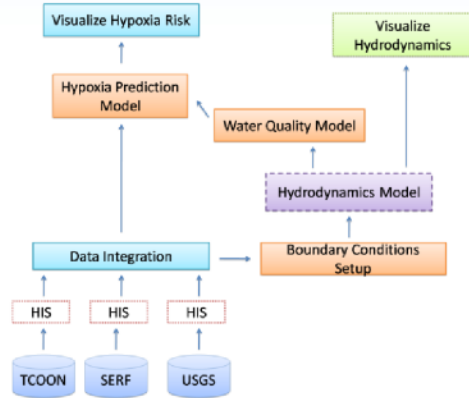
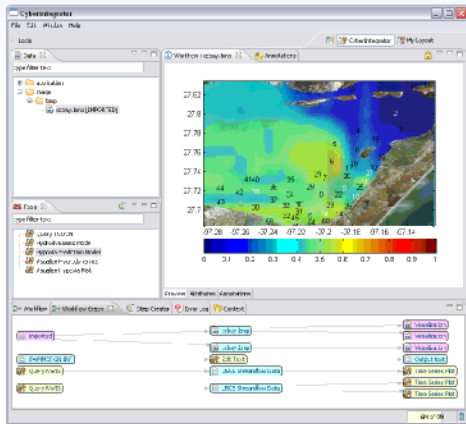


Virtual Observatories: Proof of Concept and Trials

Sectors include agriculture, first responder, maritime, health, humanitarian services, water quality, climate study, energy..



Digital Observatories



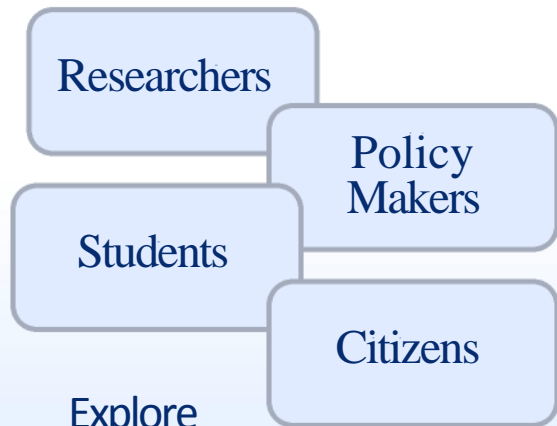
Model Publish



Observe

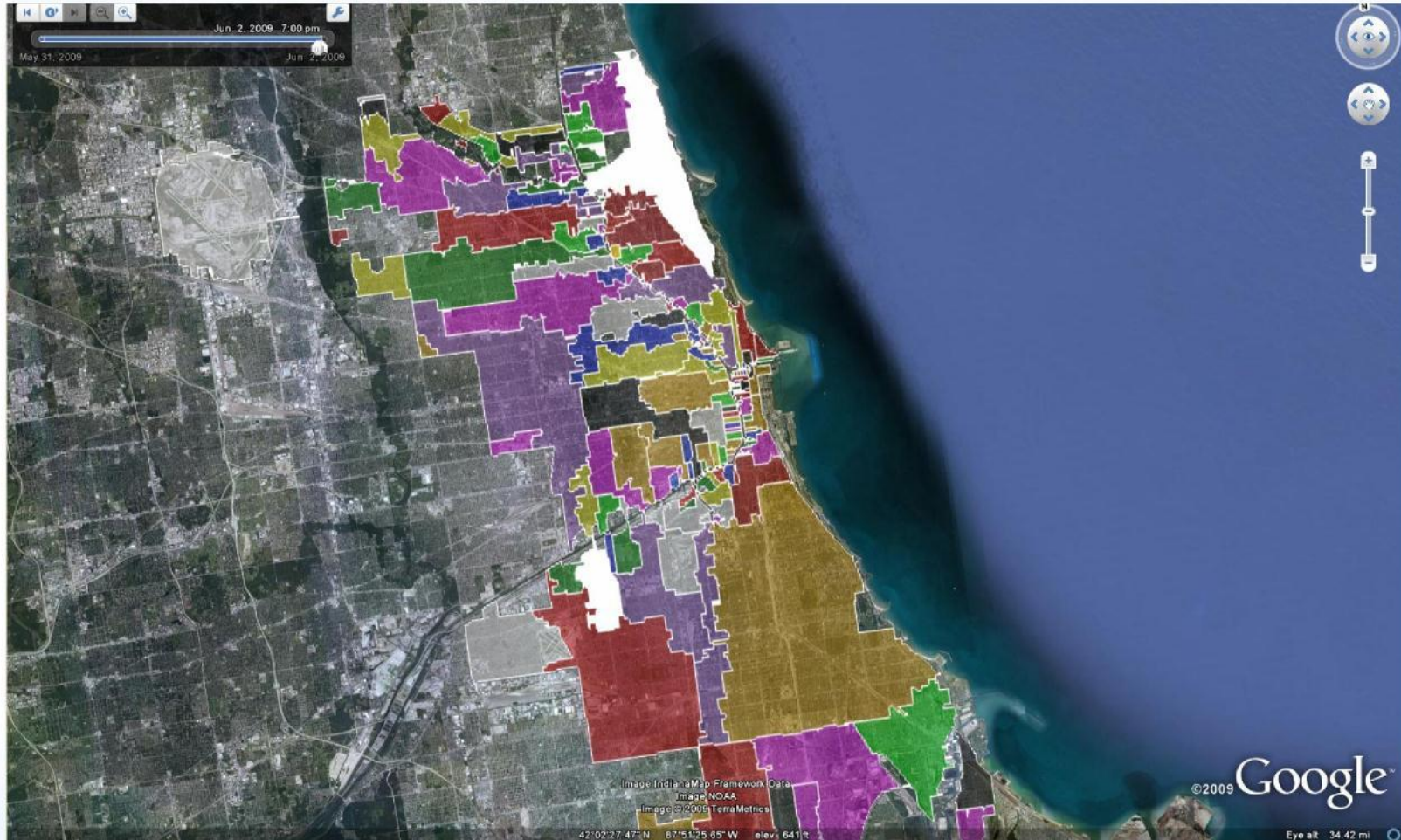


From Basic Research to Societal Impact



Understand

Virtual Sensor Result 2 : Polygon-Based Real-Time Rainfall Data



Liu, Y., et al. (2009). "Web 2.0 Geospatial Visual Analytics for Improved Urban Flooding Situational Awareness and Assessment", ACM GIS '09 , November 4-6, 2009. Seattle, WA, USA

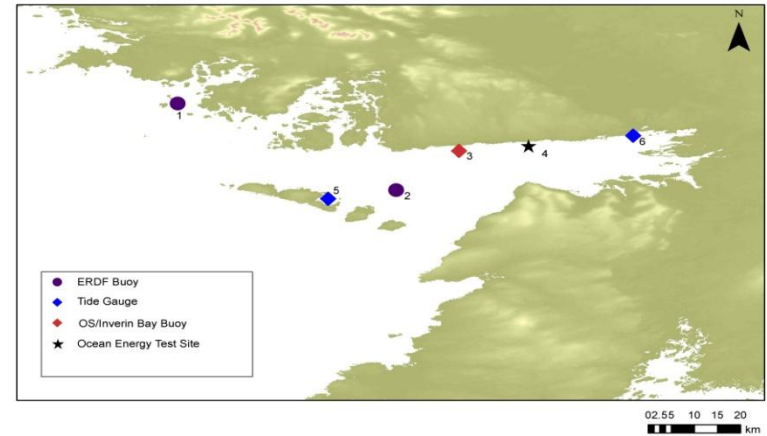


SMARTBAY GALWAY

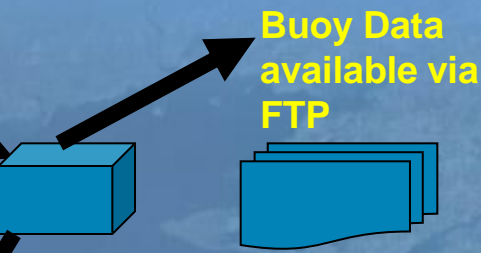
- **Sensor nodes – Primary locations**
 1. Inner Bay
 2. North Sound
 3. South Sound
- **Sensor nodes – Other locations**
 4. Galway City
 5. Kinvara Bay
 6. Ocean Energy Test Site
 7. Kilkieran Bay
- **Cable route options**

Deployment and Installation of SmartBay Pilot Infrastructure

1. Climate change Buoy, Mace Head
2. SmartBay/Offshore Aquaculture Buoy, Mid Bay
3. WiMax Test Buoy
4. Waverider Buoy, Spiddle OE Test Site
5. Tide Gauges, Inishmore and Galway Harbour
6. Corrib River Flow Gauge, Claddagh Bridge



Smartbay Sentinel



Blackbox - GPRS Telemetry



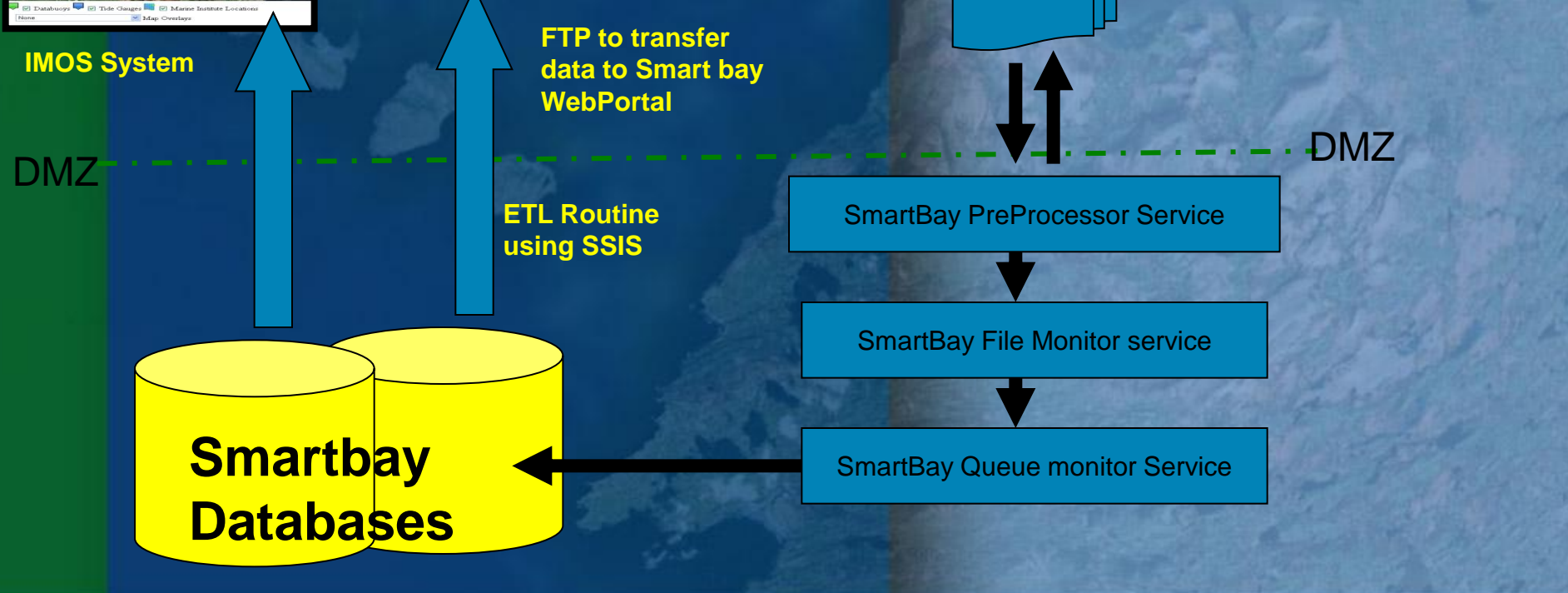
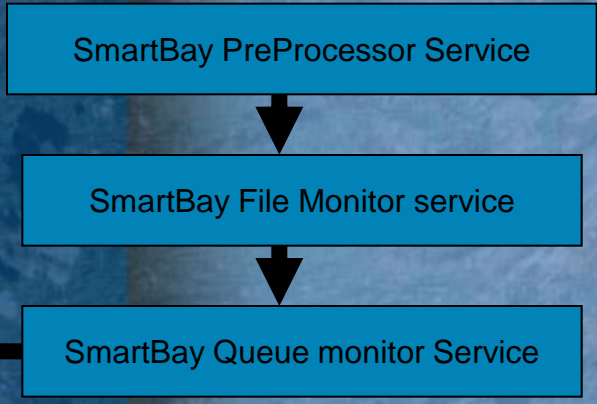
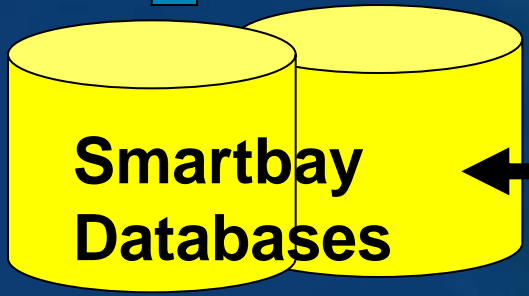
FTP to transfer data to Smart bay WebPortal

IMOS System

ETL Routine using SSIS

DMZ

DMZ



SmartBay Portal

Visualisation

Ease of Access

Alarms

Raw Data Access

Analysis

Communication

'Blink and Think'

Multi-Users

Sensor Diagnostics

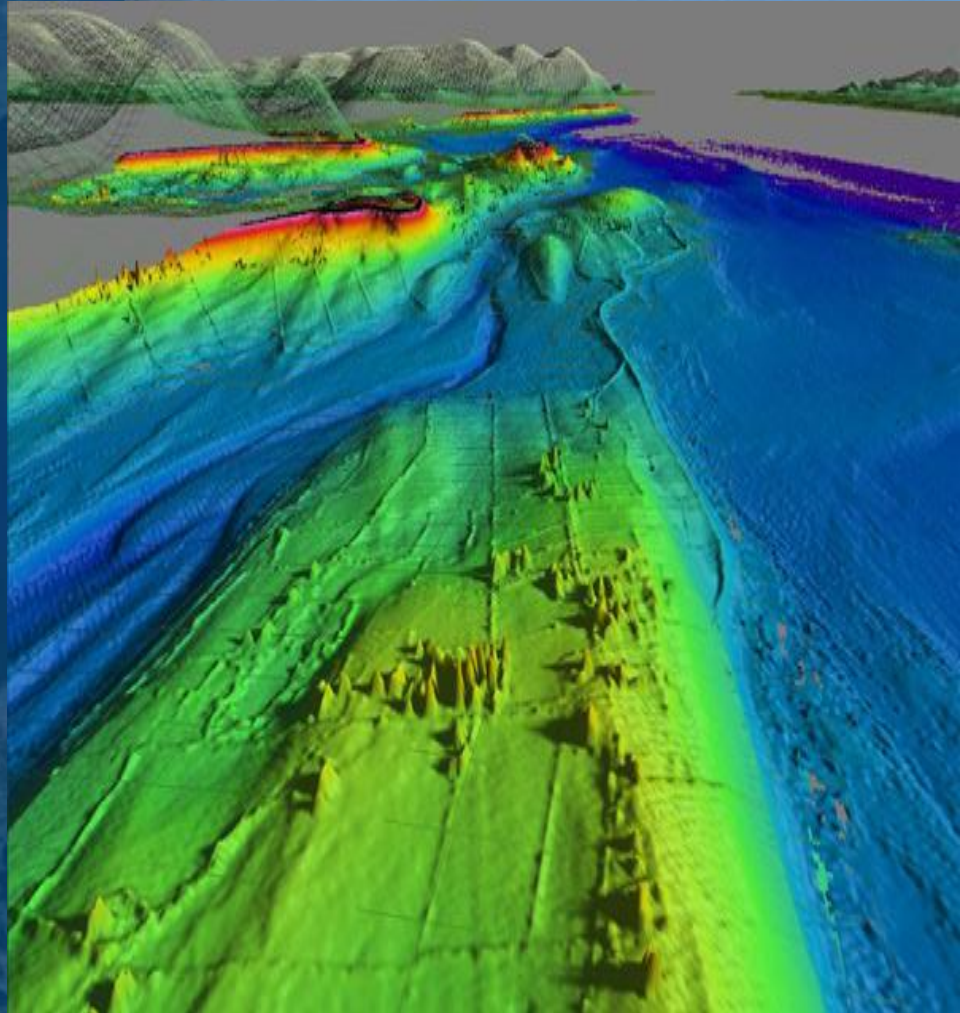
Real-time Display

Monitoring


Mapping Services



- *Integrated Mapping for the Sustainable Development of Ireland's Marine Resources (INFOMAR) - 16 Terrabytes of Data*
- Galway Bay Survey Completed in 2008 - Detailed Bathymetry data available – used in SmartBay Cable Route planning
- 3D Visualisation of Galway Bay Bathymetry as a base Layer working with Galway Bay Hydro-Dynamic Model Data



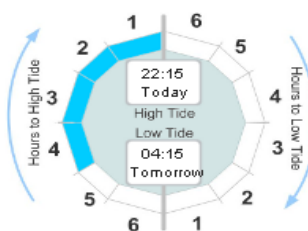
EMS Sensor Network



Air Temp. 12.6 c
 Wind Speed 8.3 m/s
 Dissolved Oxygen 1.94 mg/l
 Salinity 26.17 pss
 Location 53.1356 °N 9.5085 °W

Location: Midbay | Period: Current
 Report: Air Temp.

Tide Sensor Network



Tide Level -2.09 m
 Atm. Pressure 1021 mb
 Sea Temp. 0 c


Location: Galway | Period: Current
 Report: Tide Level

Alarm

OK

List Alarms | Add Alarm

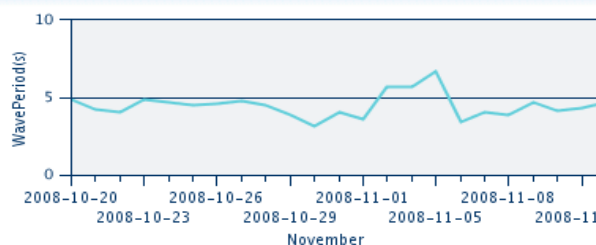
EMS Sensor Network



Air Temp. 12.700000000 c
 Wind Speed 0 m/s
 Dissolved Oxygen 5.84 mg/l
 Salinity 33.58 pss
 Location 53.3222 °N 9.9322 °W

Location: Mace Head | Period: Current
 Report: Air Temp.

Wave Power



Location: GalwayBay | Period: Month to Date
 Report: Wave Period, Wave Power

Galway Bay Map



Map Layers

POWERED BY Google

Map data ©2008 Tele Atlas - [Terms of Use](#)

Smartbay Navigation



Flooding

Attribute	Alert	Min	Max	Actual
Atm. Pressure	● ● ●	950.0	1050.0	1020.0 mb
Rainfall	● ● ●	0.0	20.0	19.0 mm
Tide Height	● ● ●	1.0	5.0	1.0 m
Tide Direction	● ● ●	240.0	60.0	60.0 deg
Wind Direction	● ● ●	240.0	60.0	230.0 deg
Wind Speed	● ● ●	0.0	20.0	5.0 m/s

Wed 19-Nov-2008 18:00

Spectral Ordinate Period

Initializing...

EcoRhythms

Corpus Christi Bay Dashboard

Corpus Christi Bay

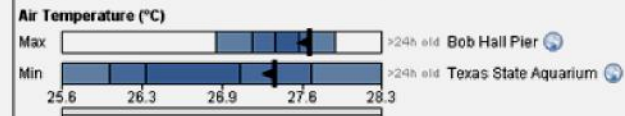
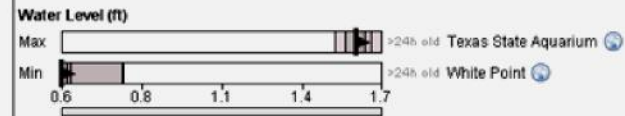
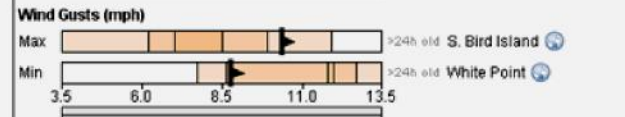
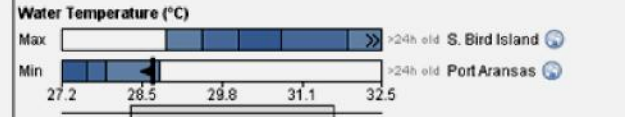
[New? Click Here](#)

Go to: Overview



Map Info

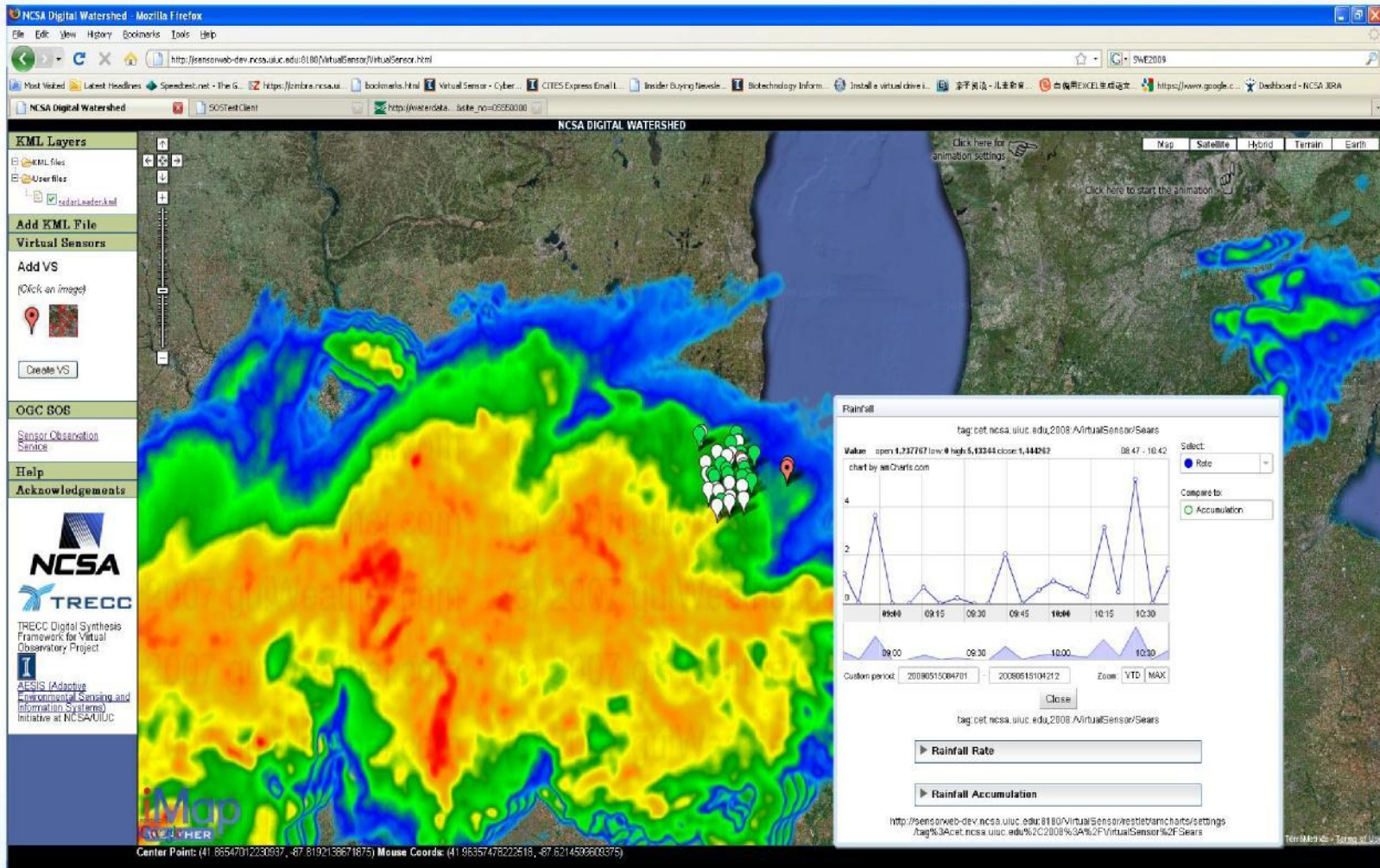
Current Min / Max Values and Locations



Min/Max Values For the Whole Bay
 All Values For a Particular Location
 Real Time View
 Historical View

Dashboard Info

Virtual Sensor Result 1 : Real Time Point-based Rainfall Data

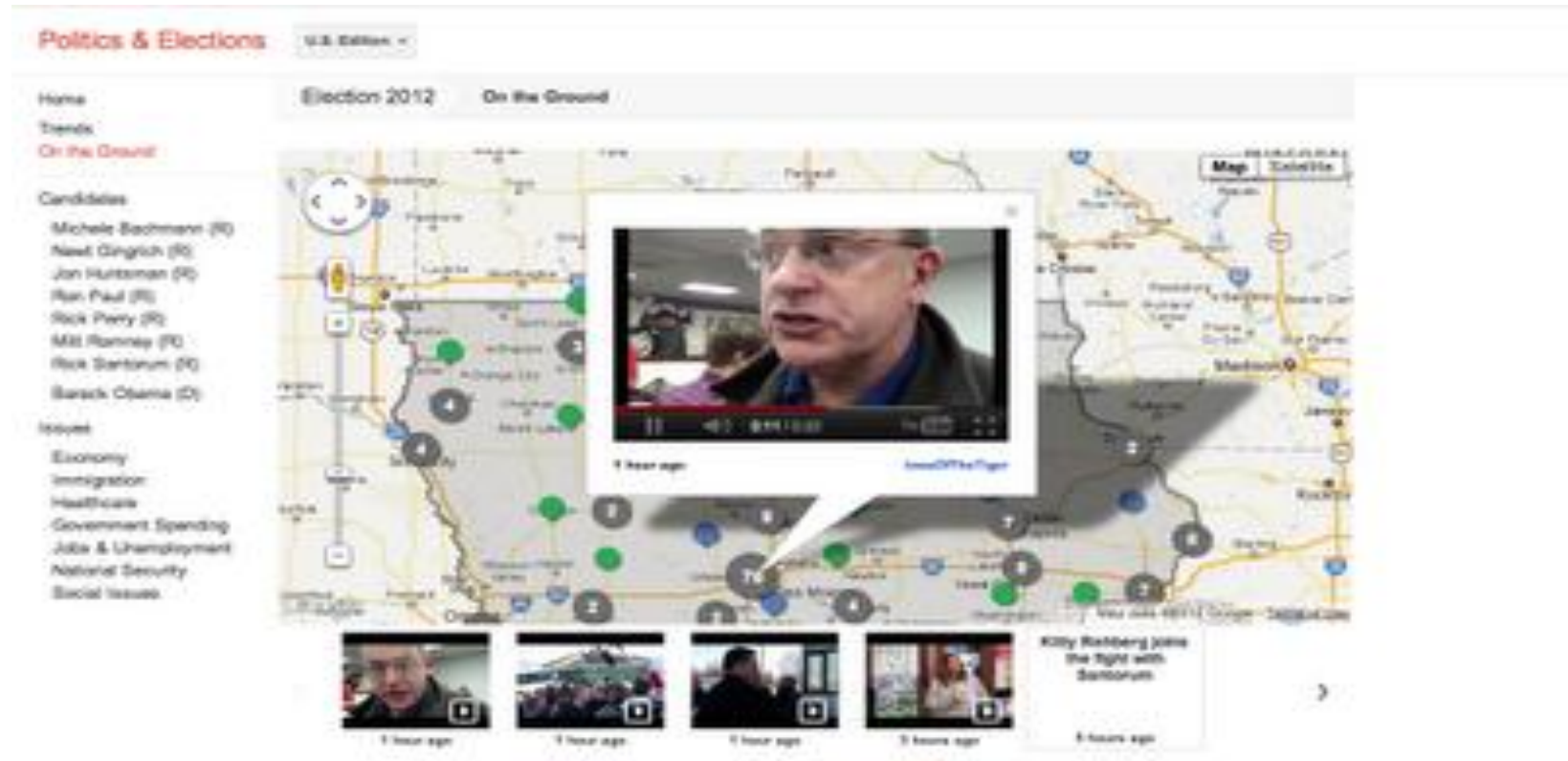


Liu, Y., et al. 2009. 'A new framework for on-demand virtualization, repurposing and fusion of heterogeneous sensors'. In Proceedings of the 2009 international Symposium on Collaborative Technologies and Systems - Volume 00 (May 18 - 22, 2009). CTS. IEEE Computer Society, Washington, DC, 54-63. DOI= <http://dx.doi.org/10.1109/CTS.2009.5067462>

Google “Election Hub” Web Portal

Features: Candidate Summary, Trends dashboard, Election Calendar, Politics & Elections Toolkit, “On the Ground”.

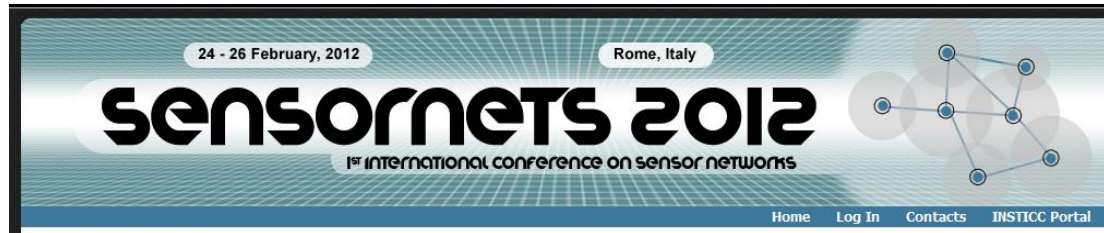
Issues Covered: Economy, Government Spending, healthcare, Immigration, Jobs, National Security, Social issues, etc.



Concluding thoughts



- Wireless technologies ... Internet Protocol ... sensors and ‘smart objects’ everywhere!
- Basic research is essential to the innovation process
- ICTs critical for research, measurement, and monitoring
- Use of Web portals provides unprecedented visibility to data
- Spectrum access & management will be increasingly important
- Military, Homeland Security, and ‘rapid response’ applications increasingly key
- Multi-national stimulus funding, NSF OCI grants, PPPs all helping to bring forth these technologies
- Significant opportunities to support the scientific lifecycle and integrated active research and reference services, which involves heterogeneous and evolving data and processes
- New Business Models and Market Disruptions are underway



Thank you!

Questions: pmlencioni@gmail.com