SensorNet: The New Science of Public Protection and Awareness

Presented by

Frank DeNap

**SensorNet Program
Computational Sciences and
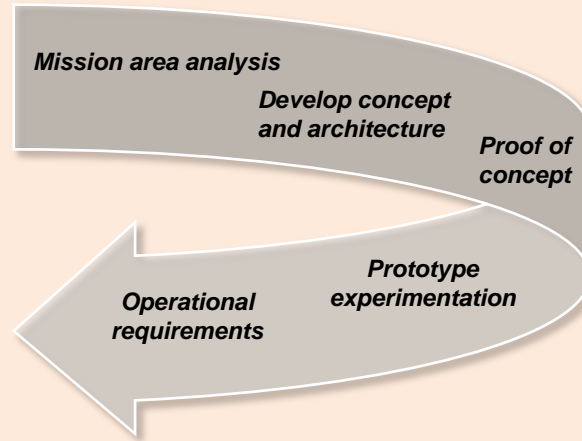Engineering Division**

SensorNet

Collection ➡ Processing ➡ Security ➡ Dissemination ➡ Knowledge generation

Intelligent

Collection

Processing

Security

Dissemination

Knowledge generation

Mission area analysis

Develop concept and architecture

Proof of concept

Prototype experimentation

Operational requirements

Real world

Politics

Operational requirements

Regulations

Technology

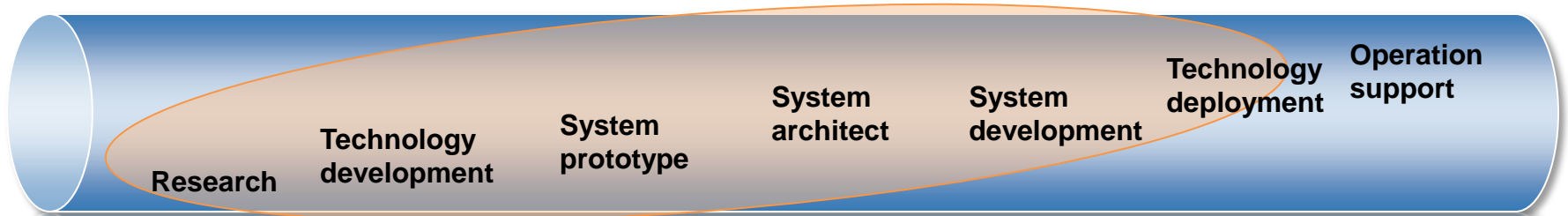**Goal:** Create an information-sharing and knowledge system in the Southeast, leveraging work from the SensorNet program

Sponsors:

DoD	SensorNet
DNDO	SETCP
DHS S&T	SERRI
DHS IP	Port of Memphis
TSA	SRRPP

DC

Virginia

Kentucky

North Carolina

Tennessee

So Carolina

Mississippi

Georgia

Alabama

Florida

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SensorNet

Research → Technology development → System prototype → System architect → System development → Technology deployment → Operation support
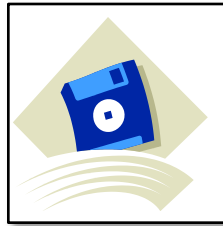

SensorNet is ORNL's research in **sensor network interoperability, infrastructure, and application models**

SensorNet is an initiative that ORNL is undertaking with the Open Geospatial Consortium, NIST, IEEE, and others **to define the set of international and open standards for sensor network interoperability**

SensorNet is the **"middleware"** that ORNL is developing as a reference implementation of the SensorNet interoperability standards. This middleware **enables an adaptive, flexible, and pervasive "web"** to interconnect sensors, data, and applications. The development contributes to the SensorNet Implementation Guide
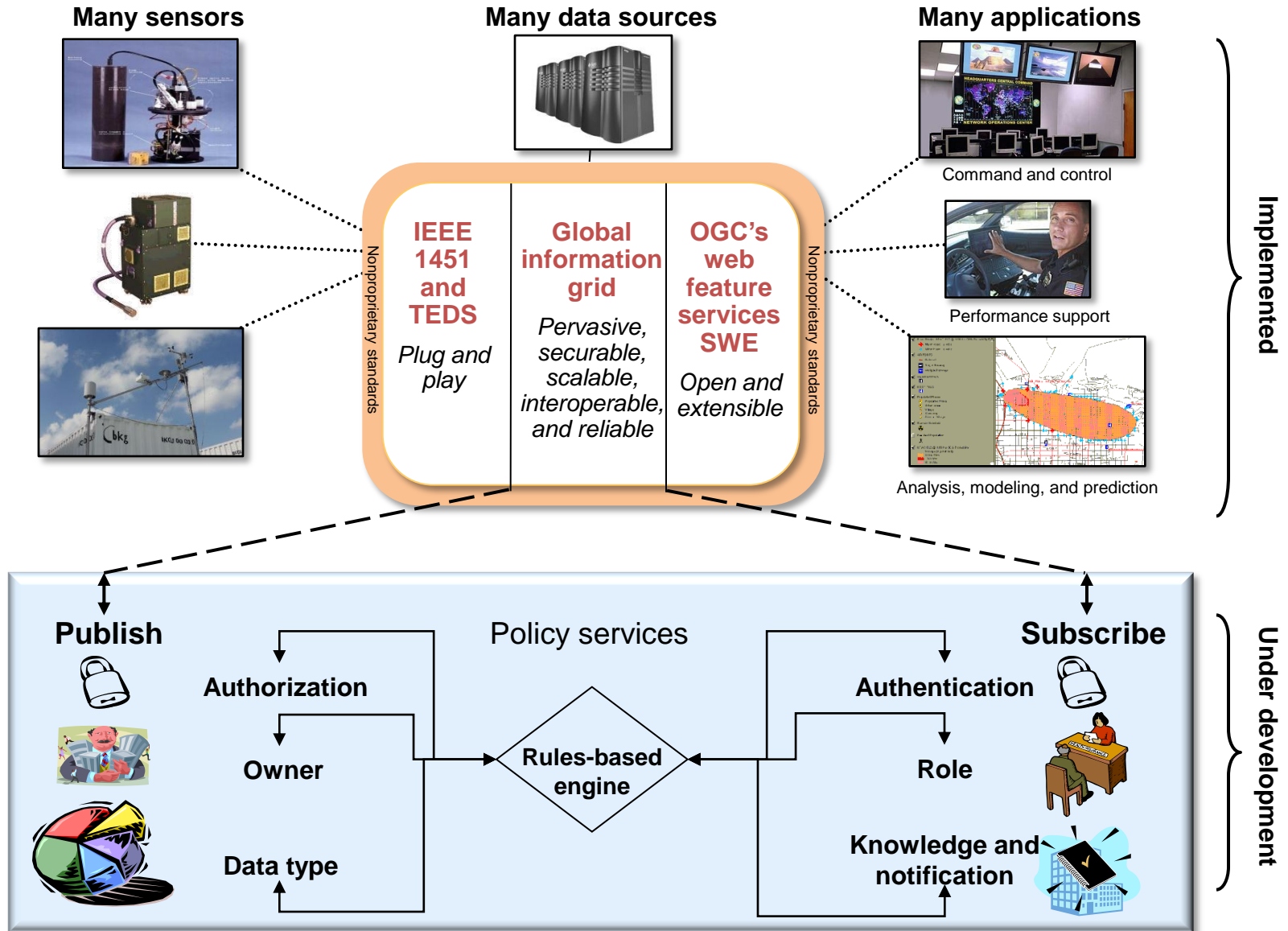

SensorNet is the **integration** of ORNL's middleware with commercial hardware, sensors, decision support software, communications, and databases to produce an **end-to-end system**
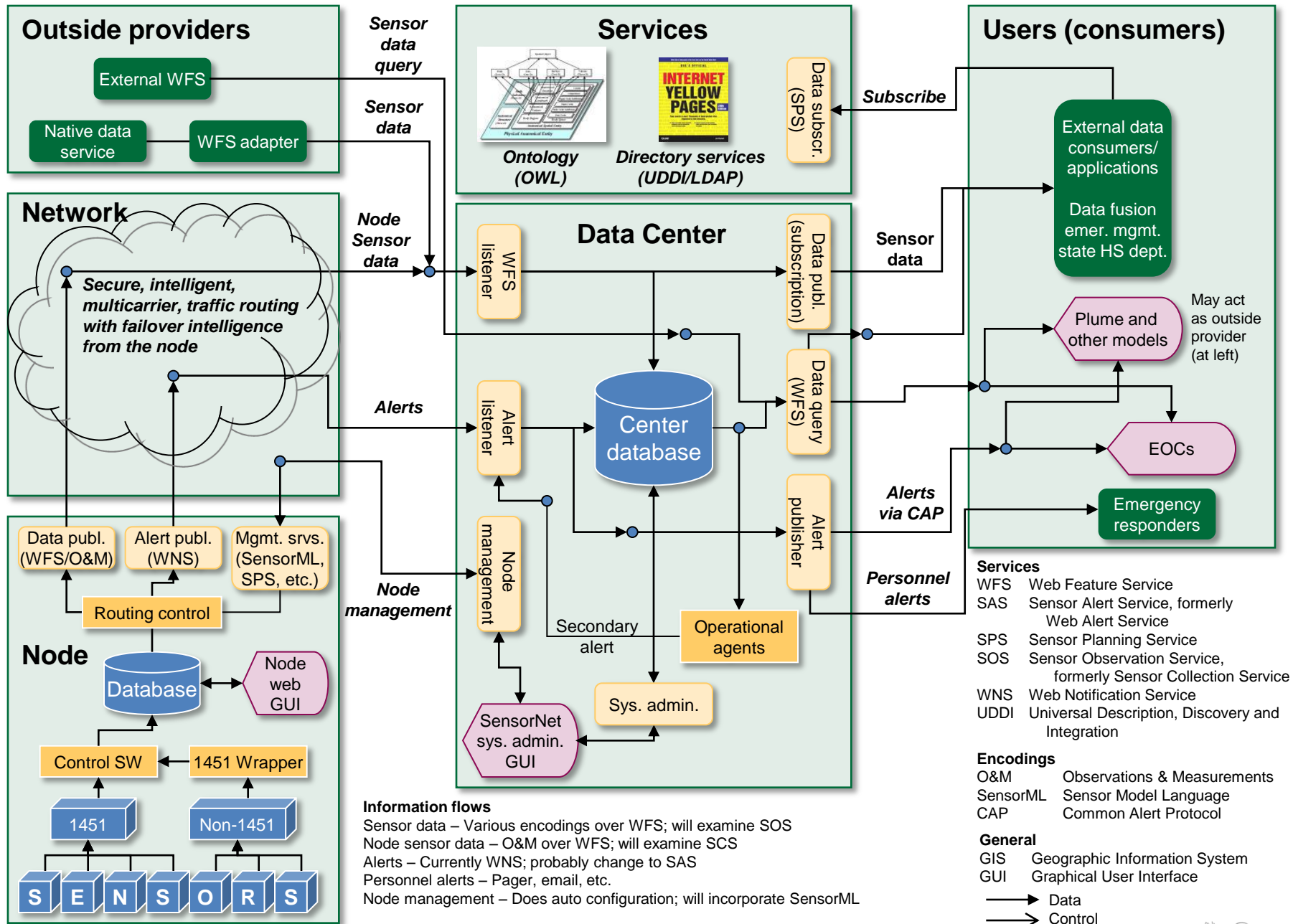

SensorNet

- Bragg experimental SensorNet test bed
- Memphis operational SensorNet test bed
- Snaps
- Snaps commercial
- Sniffer
- Watt Road weigh station test bed
- SETCP
- SRRPP
- Shelby County
- KIFC
- NOC

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Interoperability-based design

Many sensors

Many data sources

Many applications

Nonproprietary standards

IEEE 1451 and TEDS	Global information grid	OGC's web feature services SWE
Plug and play	*Pervasive, securable, scalable, interoperable, and reliable*	*Open and extensible*

Nonproprietary standards

Command and control

Performance support

Analysis, modeling, and prediction

Implemented

Publish

Subscribe

Policy services

Authorization

Authentication

Owner

Rules-based engine

Role

Data type

Knowledge and notification

Under development

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Outside providers

External WFS

Native data service — WFS adapter

Services

Ontology (OWL)

INTERNET YELLOW PAGES

Directory services (UDDI/LDAP)

Data subscr. (SPS)

Subscribe

Users (consumers)

External data consumers/ applications

Data fusion emer. mgmt. state HS dept.

Sensor data query

Sensor data

Network

Secure, intelligent, multicarrier, traffic routing with failover intelligence from the node

Node Sensor data

Alerts

Node management

Data Center

WFS listener

Data publ. (subscription)

Sensor data

Alert listener

Center database

Data query (WFS)

Node management

Alert publisher

Alerts via CAP

Personnel alerts

Secondary alert

Operational agents

Sys. admin.

SensorNet sys. admin. GUI

Plume and other models

May act as outside provider (at left)

EOCs

Emergency responders

Node

Data publ. (WFS/O&M)

Alert publ. (WNS)

Mgmt. srvs. (SensorML, SPS, etc.)

Routing control

Database — Node web GUI

Control SW — 1451 Wrapper

1451 — Non-1451

S E N S O R S

Services
WFS   Web Feature Service
SAS   Sensor Alert Service, formerly Web Alert Service
SPS   Sensor Planning Service
SOS   Sensor Observation Service, formerly Sensor Collection Service
WNS   Web Notification Service
UDDI   Universal Description, Discovery and Integration

Encodings
O&M   Observations & Measurements
SensorML   Sensor Model Language
CAP   Common Alert Protocol

General
GIS   Geographic Information System
GUI   Graphical User Interface
——→   Data
——→   Control

Information flows
Sensor data – Various encodings over WFS; will examine SOS
Node sensor data – O&M over WFS; will examine SCS
Alerts – Currently WNS; probably change to SAS
Personnel alerts – Pager, email, etc.
Node management – Does auto configuration; will incorporate SensorML

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SensorNet

OGF is an open community committed to driving the rapid evolution and adoption of applied distributed computing. Applied distributed computing is critical to developing new, innovative, and scalable applications and infrastructures that are essential to productivity in the enterprise and within the science community

OGC members are specifying interoperability interfaces and metadata encodings that enable real-time integration of heterogeneous sensor webs into the information infrastructure

TRUST, or Team for Research in Ubiquitous Secure Technology, is a science and technology center established by the National Science Foundation. TRUST brings together the top universities in security research, is devoted to the development of a new science and technology that will transform the ability of organizations (software vendors, operators, local and federal agencies) to design, build, and operate trustworthy information systems for our critical infrastructure

Developing a mobile sensor search algorithm comparing fixed versus mobile sensor deployment

Developing an efficient source-location algorithm with the minimum number of deployed sensors

Developing the technologies for tracking hazardous rail cargo, including information architecture and railcar monitoring devices

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Evolution, test, and improve

From Tennessee…

to SRRPP…

to SETCP…
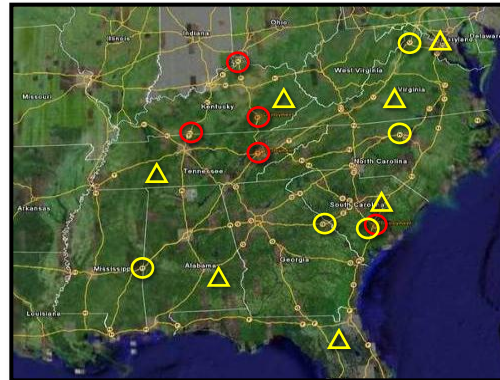
to Southern Shield

Southeast weigh stations

The radiation interdiction process

Using all the components in concert provides the greatest probability for detecting illegal radioactive material traveling within the United States
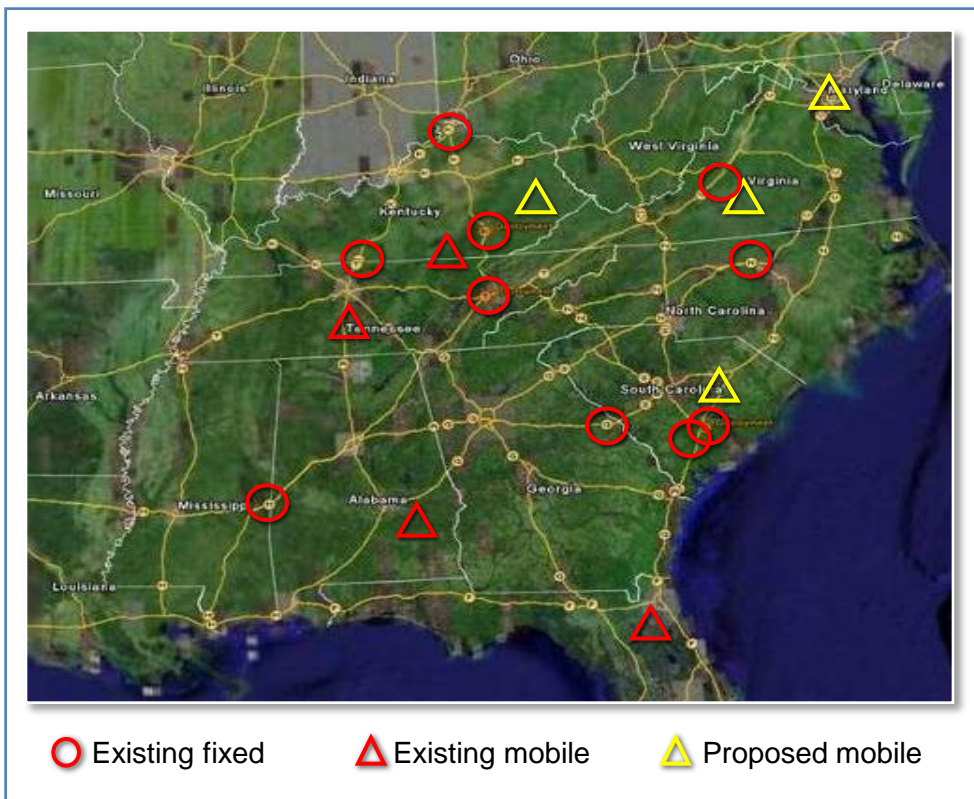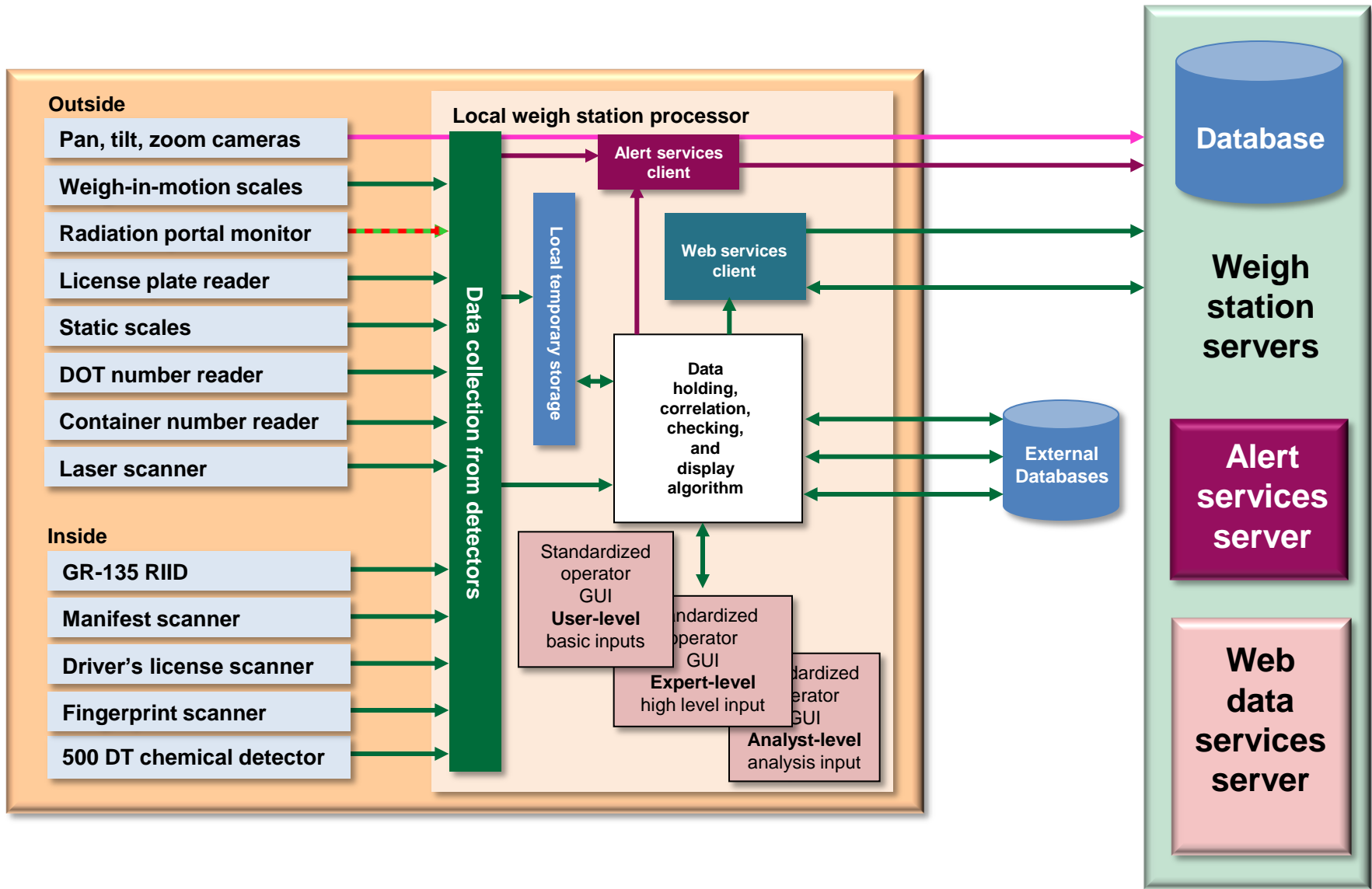

Existing fixed   Existing mobile   Proposed mobile

RPM   RIID

Knox County, Tn

AE74054

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Weigh station

Seahawk RAD/NUC detection program partners

- **DOJ/SEAHAWK**
  - **Operational lead**
  - **Funded first vehicle-based and marine-based systems**

- **South Carolina research authority/ Oak Ridge National Laboratory**
  - **System integrators**
  - **RAD/NUC detection experts**

- **DHS office of grants and training/TSA**
  - **Funded system development through grant with SCRA**

- **DHS/domestic nuclear detection office**
  - **Provided training support**
  - **Participated in technical advisory board**
  - **SE transportation corridor pilot**

RAD/NUC detection architecture

Fixed detector array (CBP)

900 MHz/EVDO wireless network
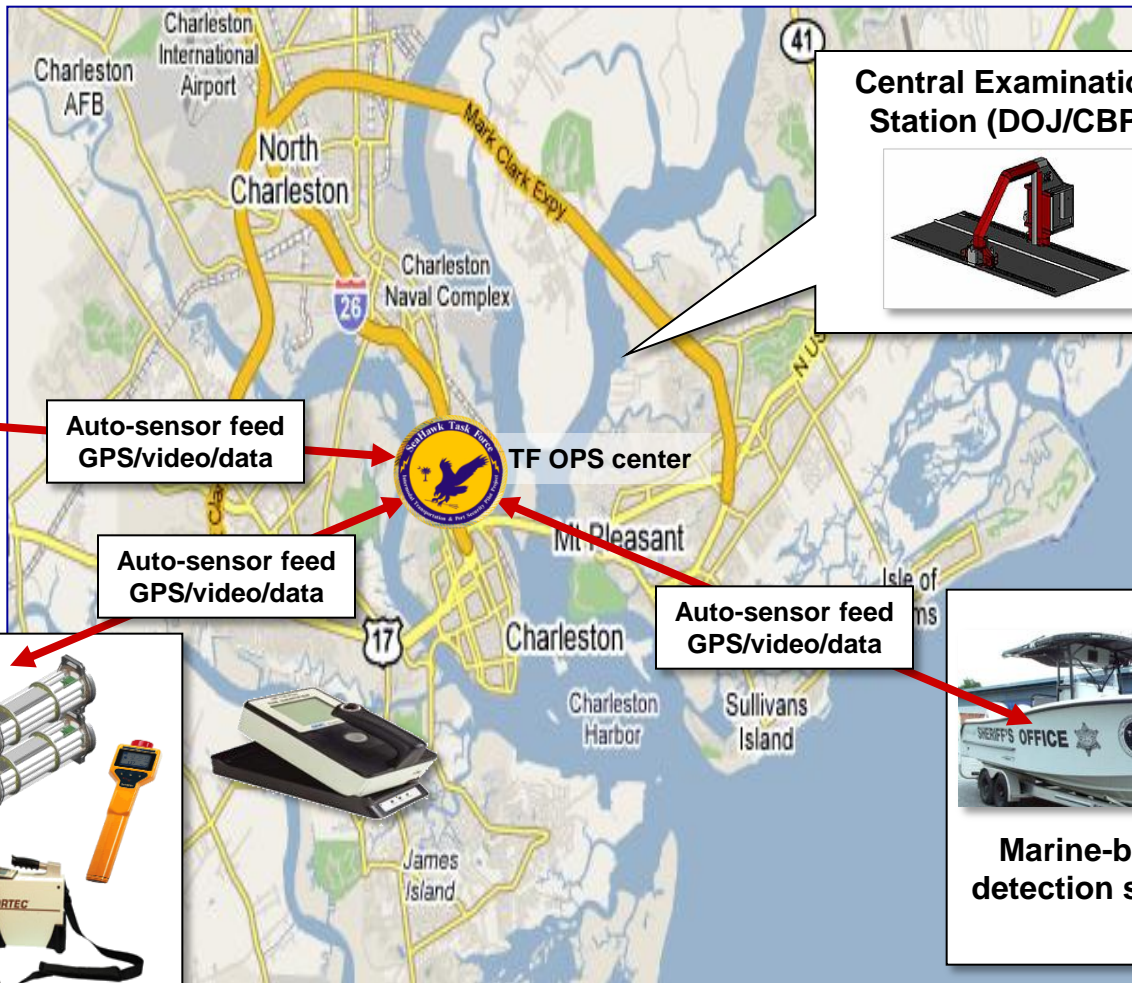
Central Examination Station (DOJ/CBP)

Other mobile equipment
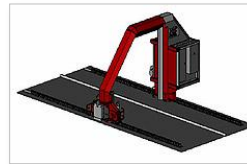
Auto-sensor feed GPS/video/data

Auto-sensor feed GPS/video/data

TF OPS center

Auto-sensor feed GPS/video/data

Vehicle-based detection system

Marine-based detection system

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Information sharing and knowledge discovery

Leverage: NOC (DHS S&T)

State fusion centers ↔ State EOC

Local/municipal command center ↔ Municipal EOC

First responders

Leverage: SETCP (DNDO)
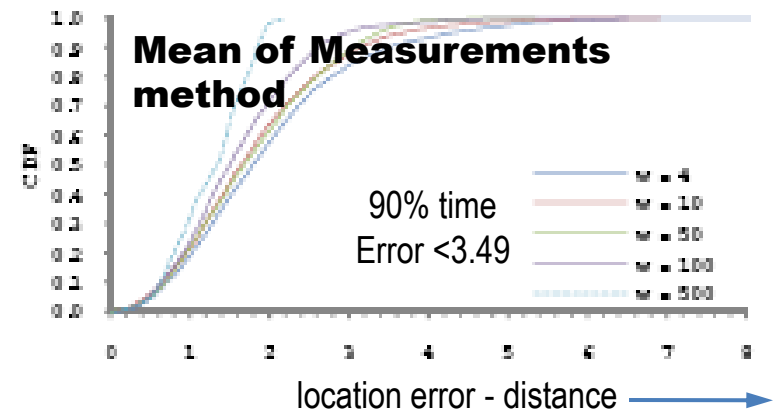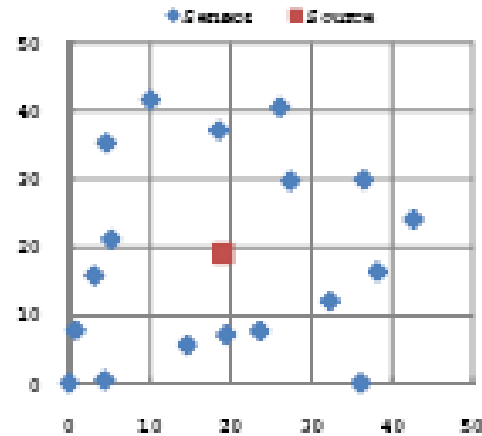Kentucky weigh stations (DHS grant)
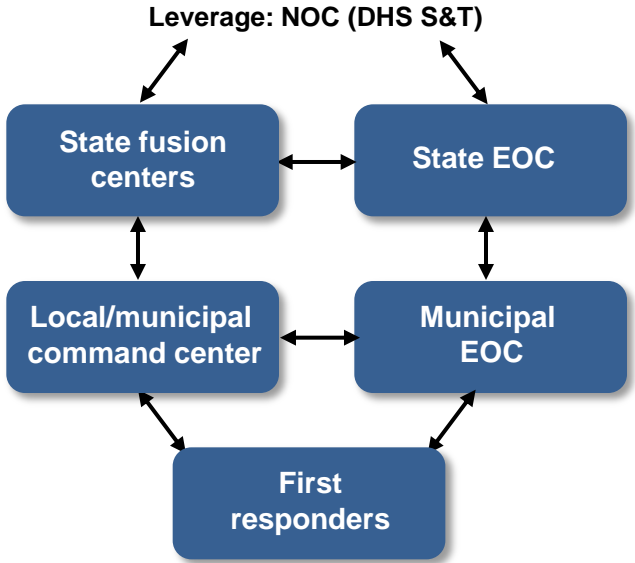
Leverage: Port of Memphis (DHS grant)
SNAPS (DHS grant)

Sensor fusion, cyber physical systems

IEEE MFI 2010: Cognitive Sensor Fusion

BEST PAPER AWARD

"Cyber-Physical Trade-Offs in Distributed Detection Networks"

Nagi Rao, Jren-Chit Chin, David Yau, Chris Y. T. Ma
and Rabinder Madan

Presented
September 6, 2010

Thomas C. Henderson, General Chair, MFI 2010

Edward Grant, Program Chair, MFI 2010
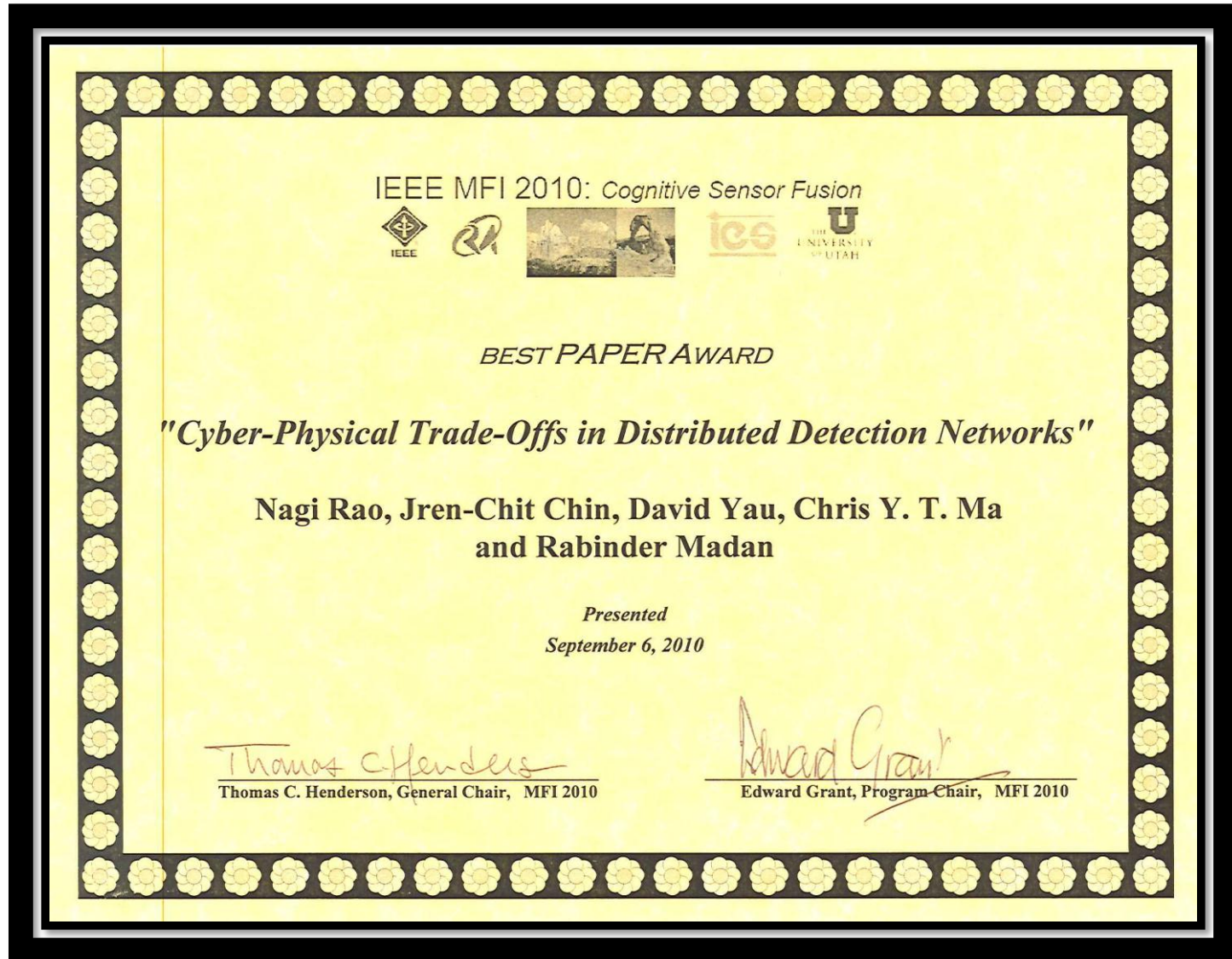
Experimental results

- **Radiation test source:**
  Cs-137 with 0.95 μCi (microcurie) strength

- **Measurements in range [140,170]**
  - **Loosely synchronized: temporal independence**

- **Number of sensor traces: 18**
  - 3738 measurements per trace

Mean of Estimators method

90% time
Error <2.56

location error - distance

measurement window size

Mean of Measurements method

90% time
Error <3.49

location error - distance
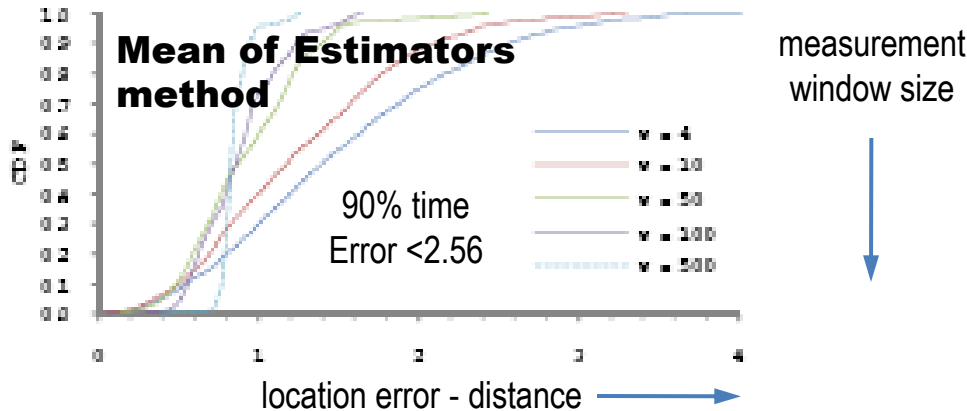
- **MoE: Performance improves with number of sensors**
  - **Improved by factor of 4 with 10 sensors compared to 3**

number of sensors

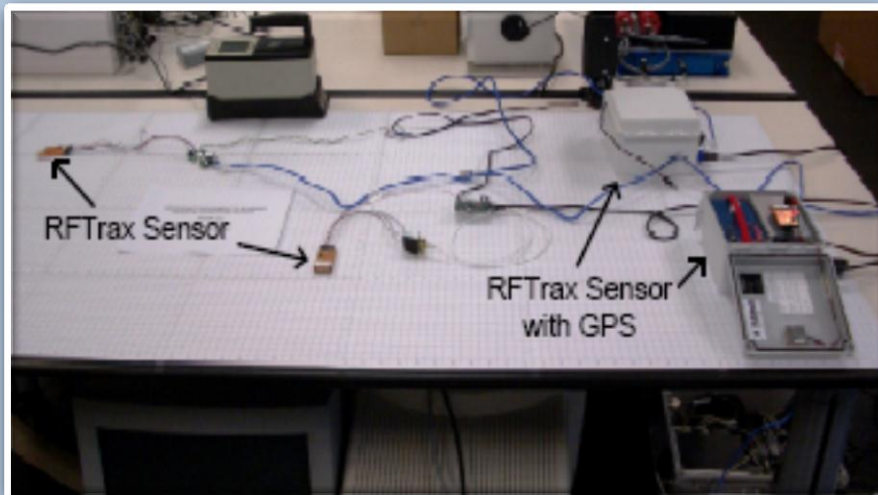OAK RIDGE
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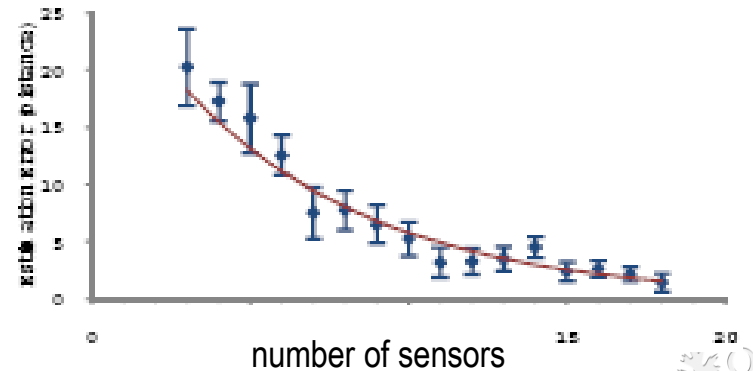
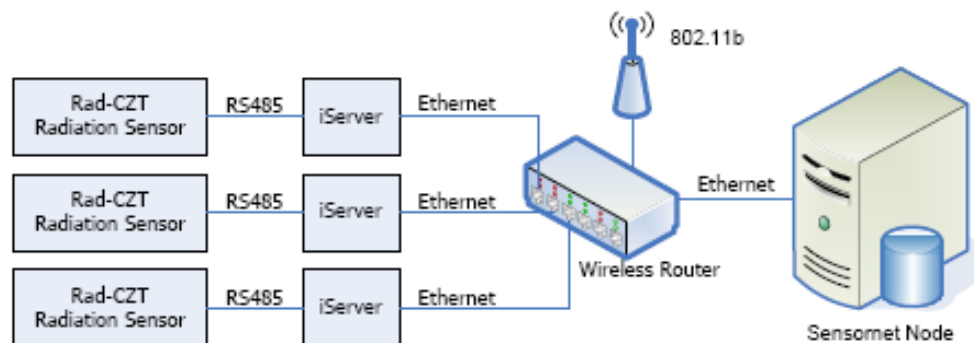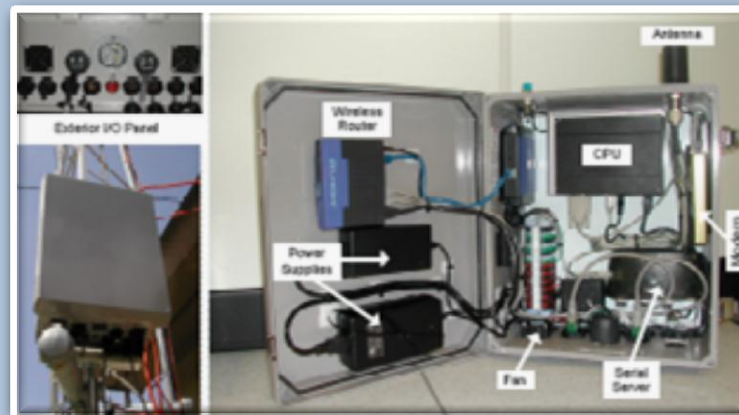# Testbed setup
Replicated at ORNL, Purdue, and UIUC

Rad-CZT gamma ray counters from RFTrax
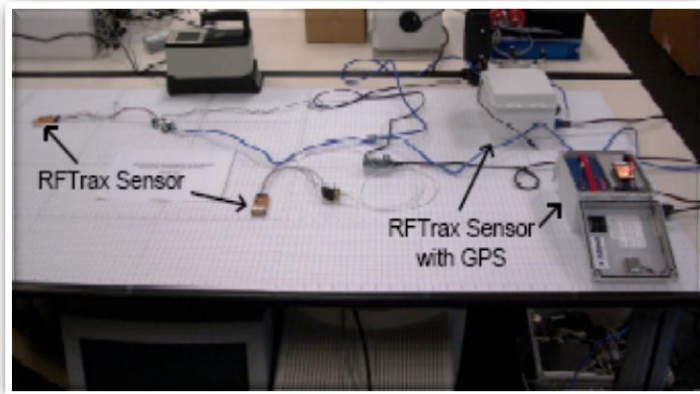
- RS485 iServer connection to server SensorNet node

**ORNL SensorNet Node
Linux Fedora core and MySQL**

Emulation testbed

- **Difficult to test sources with "nonpractical" strengths**
  - **Unsafe for human operation**
  - **Significant cleanup efforts – decontamination**

- **Emulation**
  - **Map "larger area" onto workbench: meters ⟺ inches**

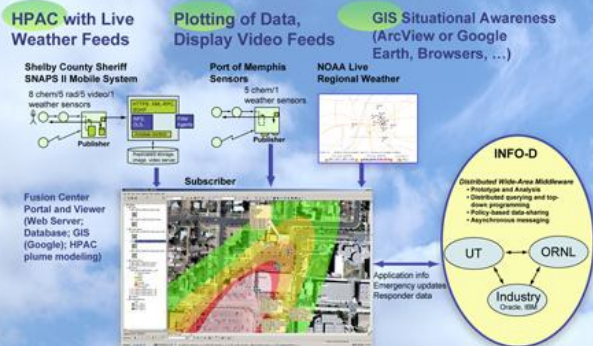$$r_{emulated} = s_f \, r_{workbench}$$

  - **Same measurements represent higher source strength**

$$A_{emulated} = s_f^2 \, A_{workbench}$$

$$s_f = 100 / 2.54 = 39.37$$

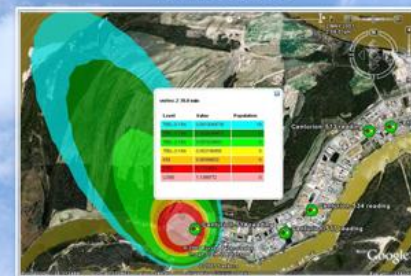 - **1472 μCi source emulated using 0.95 μCi source**
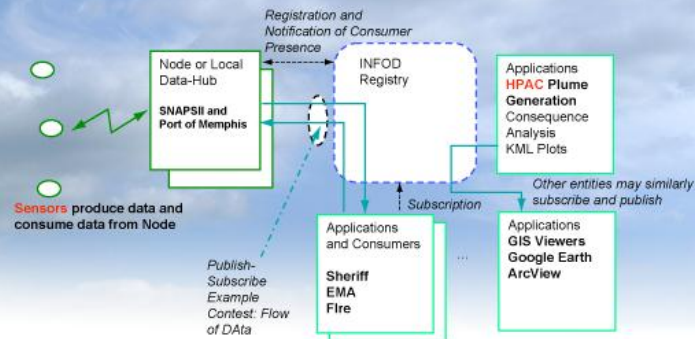
SNAPS+POM_NOAA_INFO-D

HPAC with Live Weather Feeds

Shelby County Sheriff SNAPS II Mobile System
8 chem/5 rad/5 video/1 weather sensors

Plotting of Data, Display Video Feeds

Port of Memphis Sensors
5 chem/1 weather sensors

GIS Situational Awareness (ArcView or Google Earth, Browsers, ...)

NOAA Live Regional Weather

Fusion Center Portal and Viewer (Web Server; Database; GIS (Google); HPAC plume modeling)

INFO-D
Distributed Wide-Area Middleware
• Prototype and Analysis
• Distributed querying and top-down programming
• Policy-based data-sharing
• Asynchronous messaging

UT — ORNL

Industry
Oracle, IBM

Application info
Emergency updates
Responder data

Critical Situation Information

SC Sheriffs

Other Agencies

Sharing Near-Real-Time Information

SNAPS-Sensor Network Area Protection System
Mobile Threat Detection System

Mobile, re-configurable system components, rapidly deployed, **Mobile SensorNet Operations Center**

Wireless, GPS enabled sensors with battery operations **Sensors are 100% Mobile**

Tower based "Auto-Eyes-On" from wireless video **Slew to Sensor Alert**

GIS **auto-Plume** *at Alerts*

GIS showing **GPS locations** *of Sensors*

Port of Memphis

Fixed Chemical Detection

Plume Analysis

INFOD Rapid Data Sharing

Registration and Notification of Consumer Presence

Node or Local Data-Hub

SNAPSII and Port of Memphis

INFOD Registry

Applications
HPAC Plume Generation Consequence Analysis KML Plots

Sensors produce data and consume data from Node

Publish-Subscribe Example Contest: Flow of DAta

Subscription

Applications and Consumers

Sheriff EMA Fire
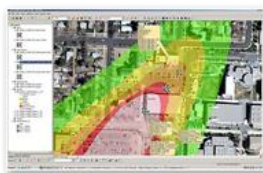
Other entities may similarly subscribe and publish

Applications
GIS Viewers
Google Earth
ArcView

Registry matches sensor data publishers and application subscribers (and consumers)

Shelby County Fusion Center

Conclusions

• Rapid data transport to and from critical threat areas
• Pre-packaged data formats that are useful to consumers
• Ease of data integration from multiple sources into one portal
• GIS display of collective understanding
• Fully 'distilled' current 'threat-condition' information
• Seamless interface to secure data

Kentucky Intelligence Fusion Center collaboration with NOC and other state fusion centers

- The Kentucky Information Fusion Center (KIFC) needs to share data and communicate with other state fusion centers as well as the National Operations Center (NOC) and Joint Analysis Center (JAC) in Washington, DC

- Data sharing services
  - HazMat data
  - Weigh station radiation data
  - Video streams

- Communication
  - Crisis management
  - Situational awareness
    - WebEOC
    - Collaboration tools
    - Computerized documentation of interaction

- The KIFC will have a map of the surrounding states indicating the location of the fusion centers for each state and NOC in Washington, DC

- The icon representing the fusion center location will be color coded to represent the crisis status of the state or the communication status with that state

- The crisis status of the state will indicate the situation in that state

Normal operation (green)   Radiation situation (red)   Terrorist incident (blue)   Currently communicating (orange)

Contact

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