Lawrence Livermore National Laboratory

NARAC Software Quality Assurance: Adapting Formalism to Meet Varying Needs

2nd Joint Emergency Preparedness and Response & Robotics and Remote Systems Topical Meeting

March 11, 2008

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NARAC-IMAAC Program

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This work performed under the auspices of the U.S. Department of Energy by
Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344

Outline

- Overview of NARAC
- Overview of Hotspot
- NARAC Quality Assurance
- SQA Activities

NARAC Provides Predictions for Assessing Atmospheric Hazards

- **Explosive dispersal of radiological material**
- **Nuclear explosions**
- **Toxic industrial chemical spills**
- **Fires**
- **Biological agents**
- **Chemical agents**
- **Nuclear power plant accidents**

What is the hazard?
Where is it going?
Who is at risk?
How do we respond?

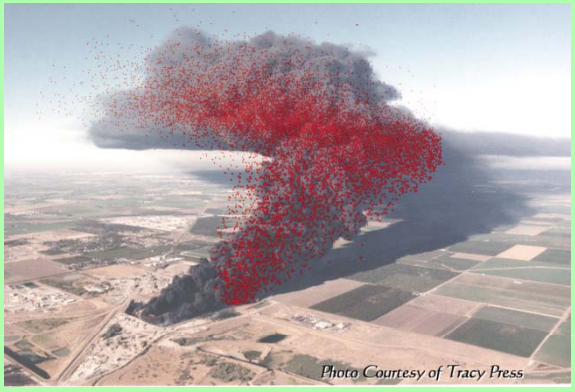
NARAC/IMAAC Provides Operational Services, Tools, Expertise for Preparedness and Response

Event Information

- **Weather data**
- **Nuclear, radiological, chemical, and biological source information**
- **Terrain, land use, and population databases**
- **Measurement data and observations**

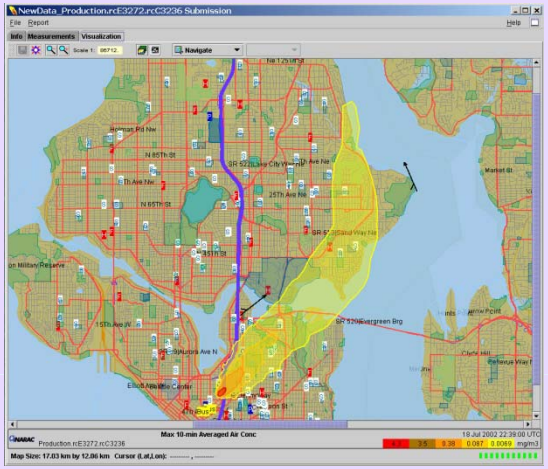
Operational Services and Expertise

- **Suite of stand-alone to advanced WMD modeling tools (multi-scale models)**
- **24/7/365 expert scientific staff (< 5 min. reachback)**
- **Detailed analysis, expert interpretation, quality assurance, and training**
- **Event reconstruction**



Actionable Information

- **Hazard areas**
- **Health effects and exposed populations and facilities**
- **Casualty, fatality, and damage estimates**
- **Protective action recommendations and response strategies**



Internal and External Models

Model	Source	Description
Hotspot	LLNL	Gaussian plume model for radioactive and nuclear material
EPICODE	LLNL	Gaussian plume model with hazardous chemical databases
BLAST	SNL	Pressure effects model for high explosives and RDDs
NUKE	SNL	Prompt dose, thermal, and overpressure effects model for nuclear weapons
KDFOC	LLNL	Gross fission products fallout effects model
COAMPS	NRL/LLNL	Mesoscale forecast model
WRF	Community	Mesoscale forecast model
GridGen	LLNL	Grid generation software for ADAPT/LODI using elevation data
ADAPT	LLNL	Diagnostic meteorological model
LODI	LLNL	Lagrangian stochastic particle dispersion model
PUFF*	SNL	Explosive plume-rise
BIM*	LBNL	Building interior modeling predicts indoor air concentrations
UDM*	DSTL	Empirical urban model
FEM3MP/ AUDIM*	LLNL	Multiprocessor computational fluid dynamics (CFD) building-resolving model

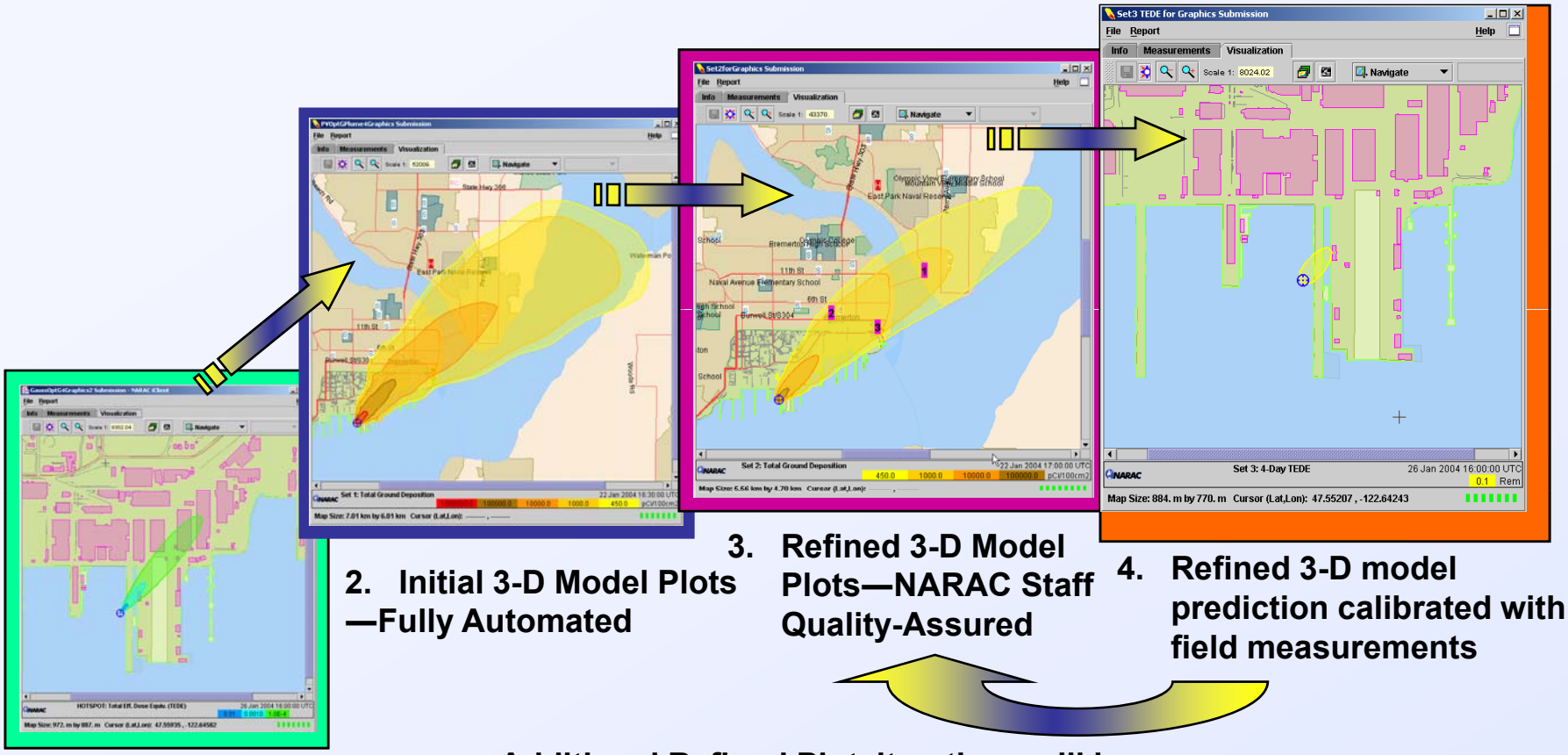
* Integration in progress

Collaborations Provide NARAC With Additional Models & Data

Stand-Alone Models from Collaborations		
Model	Source	Description
CAMEO/ ALOHA	NOAA/ EPA	Gaussian plume model with toxic industrial chemical databases
HPAC	DTRA	Plume modeling system with SCIPUFF
RASCAL	NRC	Radiological source terms and Gaussian plume/puff model for nuclear power plant releases
Turbo FRMAC	SNL	Radiological dose calculations from air and ground contamination

Forecast Model Results from External Sources		
Agency	*Model*	*Resolution/Coverage*
Air Force Weather Agency (AFWA)	MM5	45 and 15 km resolution, special regional forecasts
Fleet Numerical Meteorology and Oceanography Center (FNMOC)	NOGAPS 4.0	1° resolution, global
	COAMPS	Special regional forecasts
National Weather Service (NWS)	WRF	40 km and 12 km resolution, US (NAM)
	GFS (AVN)	0.5° and 1° resolution, global
	RUC	20 km resolution, US

Phased Concept of Operations



1. Initial Local Model Run quickly

2. Initial 3-D Model Plots —Fully Automated

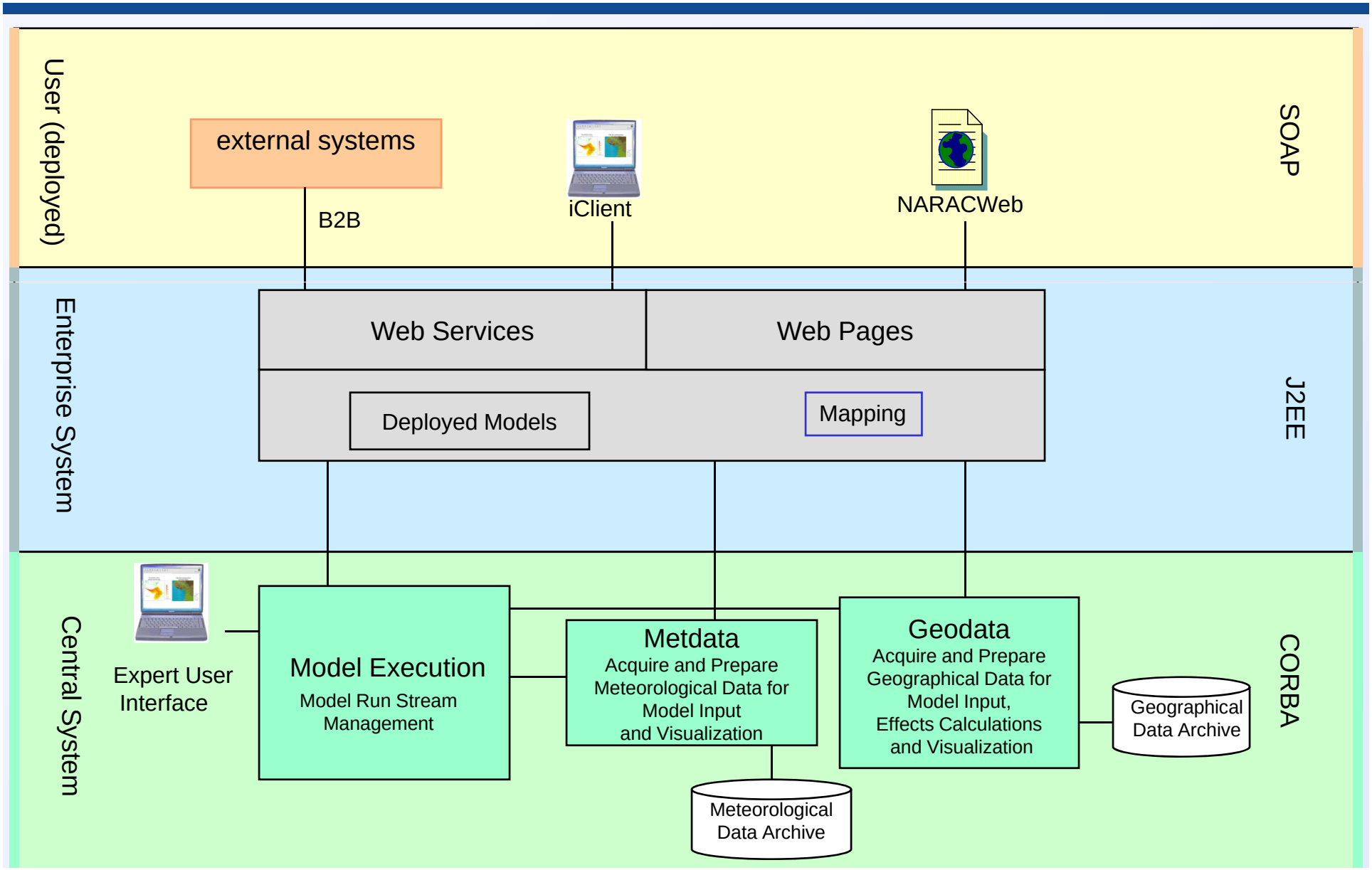
3. Refined 3-D Model Plots—NARAC Staff Quality-Assured

4. Refined 3-D model prediction calibrated with field measurements

Additional Refined Plot iterations will be made for new measurements sets

1-2 minutes | 10–15 minutes | 30-60 minutes | < 2 hours

System Architecture



NARAC Has a Proven 27-Year Record of Scientific and Operational Excellence

1973 DOE R&D Program

1979 ARAC Operational Center established

1980

Selected Events

1979 Three Mile Island reactor leak

1980 Titan Missile explosion, AR

1980 China atmospheric nuclear tests

Generation-2 system (nuclear/radiological)

1985

1986 Chernobyl reactor accident

DOE site support for toxic industrial chemicals

1990

1991 Kuwaiti oil field fires

1993 Richmond, CA refinery fire

DOE CBNP program

1996 DOE NARAC facility dedicated

1995

1997 Cassini satellite launch

1998 Tracy tire dump fire

1999 Tokaimura, Japan, criticality accident

Generation-3 system (CBRN)

2000

2002 LINC program

2003 DHS S&T

2004 DHS interim IMAAC established

2001 September 11

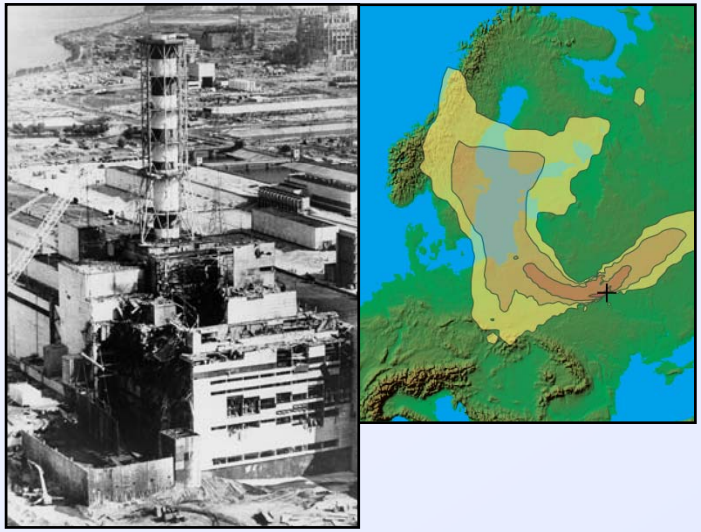
2003 Staten Island oil barge fire

2003-2004 New Years Orange Alert

2005

2004 Conyers, GA chemical fire

2006 Pluto New Horizons spacecraft launch



Chernobyl reactor building after explosion (Ukraine, 1986) and LLNL plume prediction

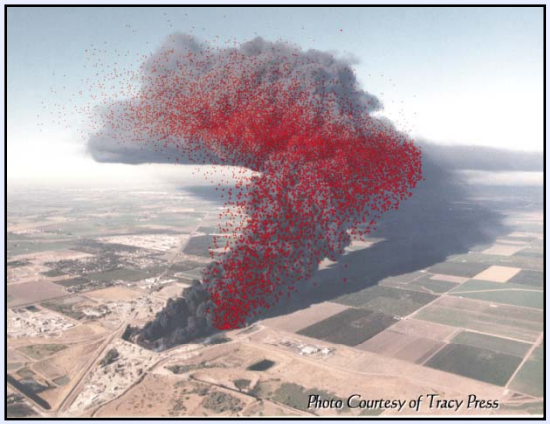
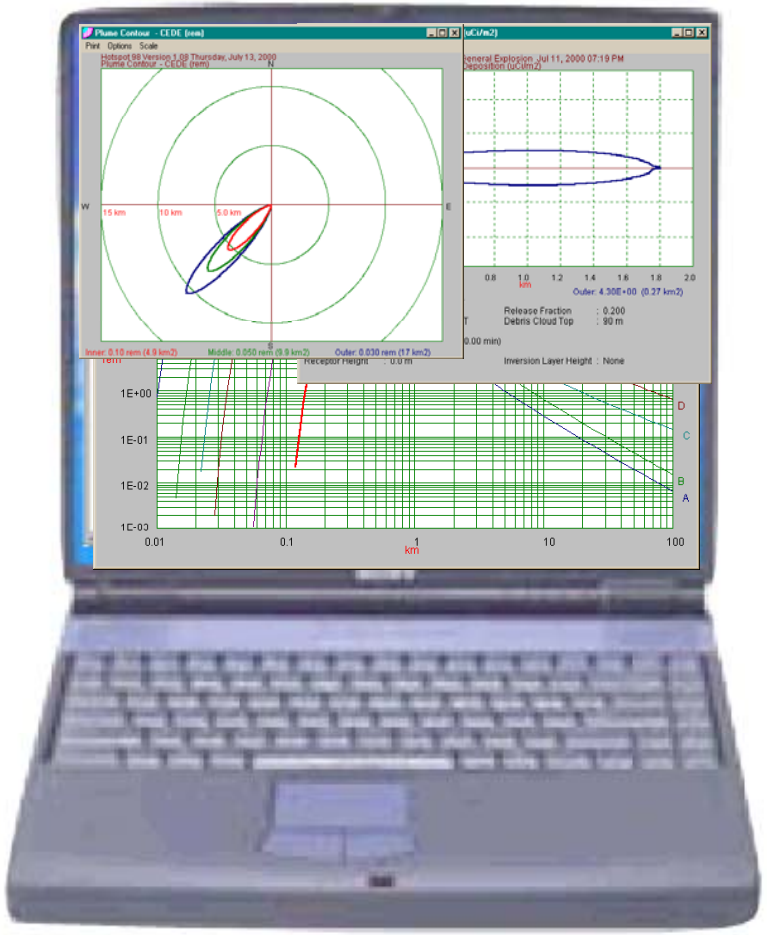


Photo of smoke from tire dump fire (Tracy, California, 1998) with plume prediction in red

Hotspot Provides Quick Dose Estimates for Radiological and Nuclear Releases

- **Multiple release scenarios (explosive, fire, general plume)**
- **Fully-integrated FGR11 (ICRP26, 30), and 13 (ICRP 60+) internal and FGR 12 external dose factors**
- **Straight-line Gaussian plume model**
- **Standalone version available via Web download: http://www.llnl.gov/nhi/hotspot/**
- **Also can run in *NARAC Web* and *iClient* user interface and maps**

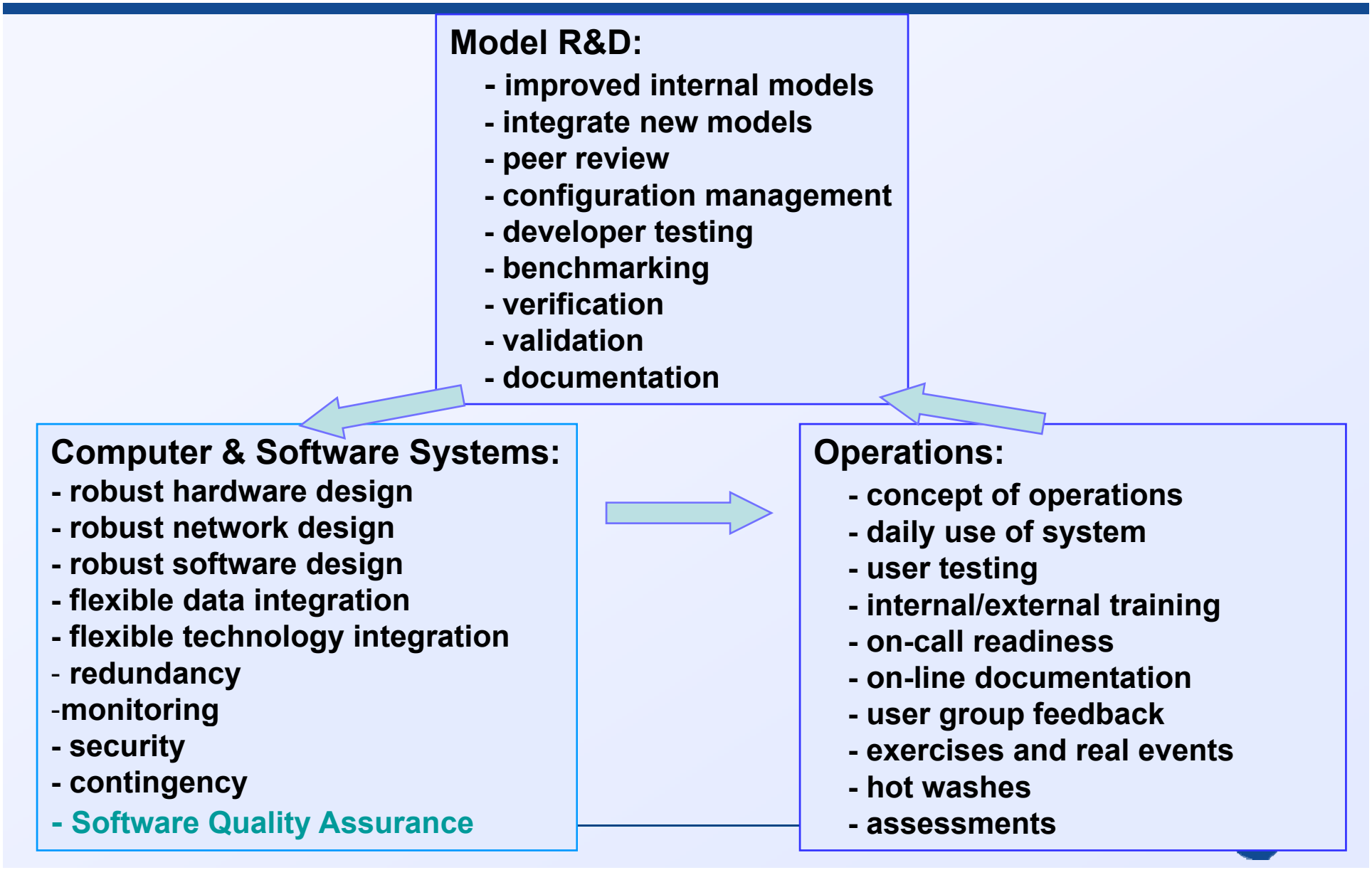


Interagency Modeling and Atmospheric Assessment Center – IMAAC

- Under DHS leadership, IMAAC coordinates dispersion modeling for atmospheric chemical/biological/nuclear hazard predictions among federal agencies
- MOU signed by 8 federal agencies: DHS, DOC/NOAA, DOD, DOE, EPA, HHS, NASA and NRC
- NARAC has been designated the primary initial provider of IMAAC capabilities
- IMAAC and NARAC roles are codified in *National Response Plan* (NRP) and *National Exercise Program* (NEP)
- IMAAC Interagency Working Group (IWG) developing Standard Operating Procedures (SOPs). Agency-specific MOU annexes are being written
- Goal is to integrate the best available scientific capabilities and data from federal, state, and local agencies, and not replace or supplant atmospheric modeling activities that are currently in place to meet agency-specific mission needs
- National training, deployment and exercise program for IMAAC Web use by DHS National Operations Center (NOC), Federal operations centers, EPA/FEMA/NOAA/DOE regional assets
- On-going interagency collaboration: operational coordination, standard plot suite and formats, data sharing

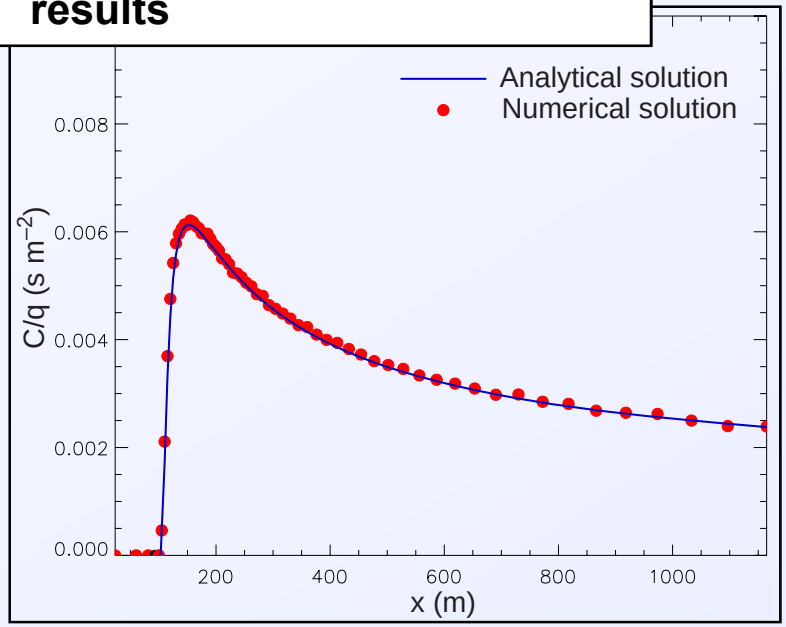
"IMAAC provides a single point for the coordination and dissemination of Federal dispersion modeling and hazard prediction products that represent the Federal position during actual or potential incidents requiring Federal coordination"
National Response Plan, May 2006

Reliable, Quality Responses



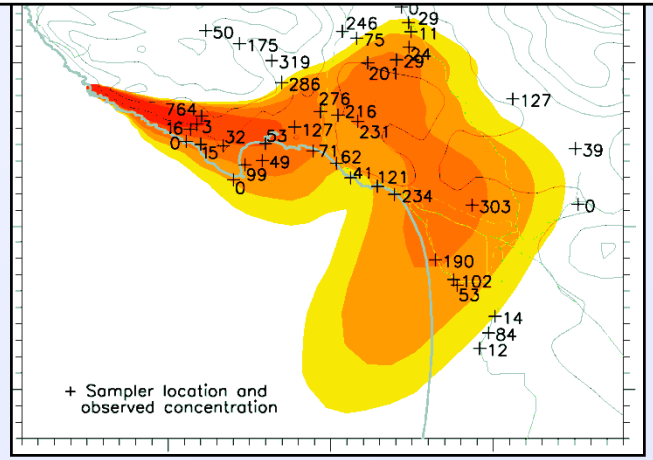
NARAC/IMAAC Models and Operations are Extensively Tested and Evaluated

- **Analytic solutions** test models versus known, exact results



- **Field experiments** test models in real-world cases

Examples: Roller Coaster, Project Prairie Grass, Savannah River Musicale Atmospheric Tracer Studies, Diablo Canyon Tracer Study, ETEX, URBAN



- **Operational testing** evaluates the usability, efficiency, consistency and robustness of models for operational conditions

Examples: Chernobyl, Kuwait oil fires, tire fires, industrial accidents, Algeciras Spain Cesium release, Tokaimura criticality accident, Cerro Grande (Los Alamos) fire

HotSpot Becoming a DOE "Toolbox" Code

- DOE has approved (pending 5 "critical" recommendations) inclusion of the HotSpot Health Physics codes into the DOE Safety Software Central Registry

- Five Critical recommendations
  - 95th-percentile dose from historical weather data -- requirement of DOE-STD-3009-94 Change Notice 3 Appendix A, subsection A.3.3 *Dose Estimation / Atmospheric Dispersion* – Not in version 2.07
  - HotSpot User manual/documentation (.PDF) and online help module
  - Formal internal configuration management plan
  - Formal V&V test process
  - Problem reporting, evaluation and notification plan per *DOE G 414.1-4 level B custom software*

ASME SQA Work Activities

1. Software project management & quality planning
2. Software risk management
3. Software configuration management
4. Procurement and supplier management
5. Software requirements identification & management
6. Software design and implementation
7. Software safety
8. Verification & validation
9. Problem reporting and corrective action
10. Training

1. Project management

- Tools
  - Gantt charts
  - Responsibility matrices
  - Java Café
  - EXCEL
  - Bugzilla
  - Word
- Long-term architectural plan
- Use of Bugzilla for requirements tracking
- Formalism is gradually increasing
- HotSpot management is being integrated with NARAC

2. Risk Management

- **Continuous evaluation of processes**
  - **Identify risks**
- **Factors mitigating risk**
  - **Experienced, committed staff**
  - **Co-located with operations/modeling staff**
  - **Operations staff use system daily**
  - **System & software constantly monitored**
  - **Steadily improving design skills & tools**

Experience (years)	0-5	5-10	10-20	20-30
people	4	5	6	3

- **Factors increasing risk**
  - **Growing requirements**
  - **Complex system**
- **HotSpot is developed by a single develop**
- **Integrating HotSpot management and procedures with NARAC should decrease risk**

3. Configuration Management

- **All system components are in version control**
- **System domains clearly separate development/production environments**
  - **Formal procedures for migrating integrated packages to production**
- **All Production domains are constantly monitored and evaluated**
  - **Statistics are evaluated regularly**
- **HotSpot releases maintained in NARAC Enterprise System version control**

4. Procurement & Implementation

- Use a variety of systems, packages and tools
  - EXCEL used to track acquisitions & licenses
- Selections are based on:
  - support of required capabilities
  - ease of integration
  - vendor reputation & previous experience
  - cost and deployment constraints
- All components are continuously evaluated
- Maintenance level is tuned to impact
- Current HotSpot procedures in this area are adequate

5. Requirements Management

- **Software requirements driven from two levels**
  - **High-level requirements set by sponsors and Program Management**
  - **Detailed requirements set by internal/external users**
- **Requirements are evaluated by software staff**
- **Requirements managed in Bugzilla**
- **HotSpot requirements management is being integrated with NARAC procedures in Bugzilla**

6. Design & Implementation

- Systems have been operational for 3-5 years
- Design & Implementation Approach
  - Formalism is tuned to scope of the work
  - Extensive use of patterns & refactoring
  - Effective use of improving tools
- Software integration is mostly continuous
- Review are tuned to task scope
- HotSpot is largely in maintenance and the design is adequately documented

7. Software Safety

- **Software components are continuously evaluated for their effect on operations**
  - **Critical components are redundant**
  - **Weak components are improved**
- **Safety design techniques**
  - **Extensive use of common design techniques**
  - **The exception is reduction of complexity**
  - **NARAC/IMAAC mission implies growing complexity**
  - **Challenge to manage that growth**
- **HotSpot has been provisionally accepted for inclusion for inclusion in the DOE Safety Software Toolkit once the 5 issues are addressed**

8. Verification & Validation

- **Verification is performed throughout the development process**
  - **Developer testing is the core of this effort**
  - **Tool-based (e.g., JUnit, WinRunner) & custom tests**
- **System validation is done by internal users focusing on new capabilities**
- **Automated tests verify existing functionality**
- **In-use tests monitor the system**
  - **Automated system checks run hourly**
  - **Failures page on-call personnel**
- **Current HotSpot testing is being supplemented with testing by the NARAC modeling, systems and operations from related but differing perspectives**

9. Problem Reporting

- **Bugzilla is used for problem reporting**
  - **Roles are assigned for managing Bugzilla entries.**
  - **External customers issues are entered into Bugzilla by Customer Support**
- **The coverage of the changes being tracked is improving**
- **Corrections are tracked through V&V into production**
- **HotSpot problem reporting is being migrated from the current informal e-mail approach to the NARAC procedures built on Bugzilla**

10.Training

- Training for internal users
  - Presentations are given to the internal users
  - Web-based documentation
  - Internal users maintain a user's guide
  - Most internal user activities use the system
- Training for external users
  - Documentation on the NARAC Web page
  - Customer Support training
  - Formal classes: remote and at NARAC
- Several NARAC Staff are becoming increasingly familiar with HotSpot and will eventually supplement the current training efforts

Current SQA Activities

- Focusing on LLNL SQAP
  - Graded approach to software risk
  - Gap analysis
  - Updating NARAC SQA, Test & CM Plans
  - Improving suite of automated tests
  - Tracking requirements more precisely
- Working with the NARAC/IMAAC Model VV&A effort
  - Analytic tests/field experiments/operational use
  - Updating model documentation
  - Maintaining benchmark suite
  - Automating model V&V tests
  - Clarifying procedures for VV&A
  - Evaluation strategy for external models
- Completing resolution of HotSpot SQA shortfalls

Overview

- NARAC is more than a model
  - NARAC incorporates multiple models
  - NARAC provides a range of services
  - NARAC services are supported by operational scientists
- All activities in NARAC are Quality Assurance related
  - All model and system development activities address shortfalls in current capabilities
  - All operational activities are focused on providing high quality products
- Formal procedures are balanced with a flexible environment so that new capabilities can be added efficiently
- HotSpot is progressing steadily towards correcting the shortfalls identified by the DOE Safety Software Committee

For more information

Web: http://narac.llnl.gov

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A Comprehensive Approach Ensures Quality, Reliability, and Accuracy