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Revised Excerpts from CBNP Modeling & Prediction: LLNL History

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CBNP Modeling & Prediction: LLNL History

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(Excerpted / revised by Gayle Sugiyama)

The DOE Chemical and Biological Nonproliferation (later National Security) Program (CBNP) introduced a period, from the mid-1990's through the mid-2000's, of sustained scientific and technological growth for the National Atmospheric Response Advisory Center (NARAC). The CBNP was a multi-laboratory and multi-thrust area program that drew on the strengths of each institution while enabling the laboratories to collaborate and work together. The CBNP was moved to the Department of Homeland Security (DHS) Science and Technology Directorate when DHS was created.

In the mid-1990's, public concern over the possibility of a terrorist attack within the US, fostered congressional interest in a national civilian biodefense program. Senators Nunn, Lugar, and Domenici authored legislation to place funding into the DOE for the purpose of bolstering civilian biodefense with national laboratory technology. The activities conducted within the CBNP and associated programs ranged from scientific discovery to model development and validation to implementation in operational capabilities to support emergency response. The CBNP was executed in four elements: Biodetection, Bioinformatics, Fate and Transport, and Decontamination and Restoration. The Fate and Transport element was subsequently renamed Modeling and Prediction.

Modeling and Prediction (M&P)

The M&P research effort at LLNL had four main components:

- Urban plume dispersion modeling
- Urban field studies
- Decision-support tool development
- Operational plume modeling

The objective of these efforts was to develop and experimentally validate a system of multi-scale atmospheric transport and fate modeling capabilities for predicting the consequences of CB agent releases in urban environments and to implement these capabilities into the NARAC emergency response system at LLNL.

The LLNL modeling approach was to develop a suite of multi-scale models to predict the details of the complex flow around individual buildings and arrays of buildings, as well as the broader pattern of plume dispersion over the city and surrounding suburban areas. On the regional scale, NARAC's ADAPT diagnostic meteorological data assimilation model and the Navy's COAMPS numerical weather prediction model were adapted to the urban environment through the development of urban canopy and turbulence parameterizations that account for the effects of building drag, turbulence production, radiation balance, anthropogenic heating, and wall and rooftop heating and cooling. These models were coupled to NARAC's LODI dispersion model to

simulate urban transport and dispersion. To address details associated with building-scale flow, LLNL also developed a computational fluid dynamics (CFD) and dispersion model (FEM3MP) that explicitly incorporated the effects of individual structures.

Urban Field Studies

In order for these newly-developed models to be accepted within both the scientific and emergency response communities, they needed to be validated with data from field-study experiments. The first opportunity to obtain such data came in 2000, when the Secretary of Energy challenged the DOE CBNP to provide a biodefense structure for the 2002 Salt Lake City Winter Olympic Games. Prior to the games, a series of tracer release experiments, named URBAN 2000 led by LLNL, were performed in Salt Lake City. Data from these experiments was used by the CBNP M&P team in their initial model validation studies.

The major source of model validation data for the M&P effort was obtained a few years later from a follow-on tracer experiment. In July 2003, the DoD Defense Threat Reduction Agency (DTRA) and the DOE/DHS CBNP joined in an effort to conduct the Joint Urban 2003 atmospheric dispersion study in Oklahoma City. Led by PNNL, the field study included numerous investigators from LLNL, other government laboratories, universities and private companies. Additionally, investigators from other federal and foreign government agencies (UK Defense Science and Technology Laboratory and the Canadian Research and Development Laboratory) participated in the study. Data from the tracer releases measured the influence of urban effects, including street canyon channeling, building-induced circulations, and vertical motions, on the near-field atmospheric dispersion pattern. Within buildings, important exposure differences were found to exist depending upon building (HVAC) operation and emergency actions that might be implemented during a release.

Decision Support Tool Development: NARAC Operational Capabilities

Transforming CBNP M&P research into an effective operational emergency response capability involved a major software development effort. Extensive geographical, CB agent property, toxicity and effects, population, urban land-use, and building footprint databases were added to the NARAC system. Building infiltration models and databases developed at LBNL were also integrated into NARAC to estimate indoor exposures from outdoor releases, along with prototype coupling of subway (developed by ANL) and NARAC outdoor transport and dispersion models. A final software development effort was the creation of the NARAC Web - an Internet-based software tools that provides emergency managers and responders with reach-back to NARAC tools and expert analysis as well as the ability to share information with other agencies involved in a response.

Decision Support Tool Development: Local Integration of NARAC with Cities (LINC)

The events of September 11, 2001 heightened concern over the release of airborne CB agents within the urban environment and increased local government interest in appropriate emergency planning, hazard assessment and response tools, and training. With the assistance of Public Technologies, Inc., five pilot cities (Seattle WA, Fort Worth TX, Cincinnati OH, New York City

NY, and Albuquerque NM) were selected to integrate, test, and evaluate NARAC technology in their existing local response capabilities. The effort included the integration of NARAC software capabilities with local government computer systems, the development of joint operational procedures, and the customization of NARAC tools and databases to meet local emergency management and response needs. The pilot cities contributed thousands of staff hours to the integration effort and to testing the use of the LINC capability in their training, drills, exercises and incidents. The potential value of NARAC to local agencies and their regional partners was demonstrated in more than a dozen major exercise and real-world toxic industrial chemical release events in which NARAC products and services greatly aided emergency response decisions and multi-agency coordination.

Operational Interagency Modeling and Atmospheric Assessment Center (IMAAC)

In April 2004, the Homeland Security Council authorized the creation of the Inter-Agency Modeling and Atmospheric Assessment Center (IMAAC) under DHS leadership and designated NARAC as the primary interim provider of IMAAC products. The IMAAC's designated role is to coordinate "Federal dispersion modeling and hazard prediction products that represent the Federal position" during actual or potential incidents requiring federal coordination. NARAC served as the primary operations hub of the IMAAC from its foundation through September 2012. DOE/NARAC continues to serves as the technical lead for radiological/nuclear modeling for the Department of Homeland Security-led (DHS) IMAAC.