Environmental Hazard Prediction Thrust Area Overview

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Joint Science and Technology Office Defense Threat Reduction Agency

CBIS S&T Conference Plenary Session
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Environmental Hazard Prediction

- Why we're here: Warfighter support through technical improvement of JEM, JWARN, JOEF
  - Primarily supporting JEM

- Are dispersion models good enough?
  - Need for continued progress in dispersion modeling and related work *in particular areas*

- Program structure focused on known limitations in dispersion modeling capabilities

Environmental Hazard Prediction Thrust Area Evolution

- Past: DoD environmental hazard S&T performed mostly independently by DTRA, Navy, Army
  - Lack of coordination within DoD
    - Duplication in some areas
    - No capability or programs in other areas

- Last year: Began to coordinate efforts
  - Developed S&T plan, addressing joint program needs
  - Began developing, managing projects to address key areas

- Current: Integrated programs leveraging capabilities across DoD, collaboration with US govt, universities, companies, foreign countries
  - Meeting CBDP needs, reducing duplication of effort

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Environmental Hazard Prediction Thrust Area Objectives

- Objective: Provide technological capabilities to meet stated requirements in CB defense programs

- Provide *core system* capabilities, *enabling* capabilities

- *Core system*: components of JEM, JWARN, JOEF

- *Enabling*: provide data needed by JEM, JWARN, JOEF to function

- Requirement: Ensure technological capabilities are in place to enable JEM, JWARN, and JOEF to work, when called for by development schedules

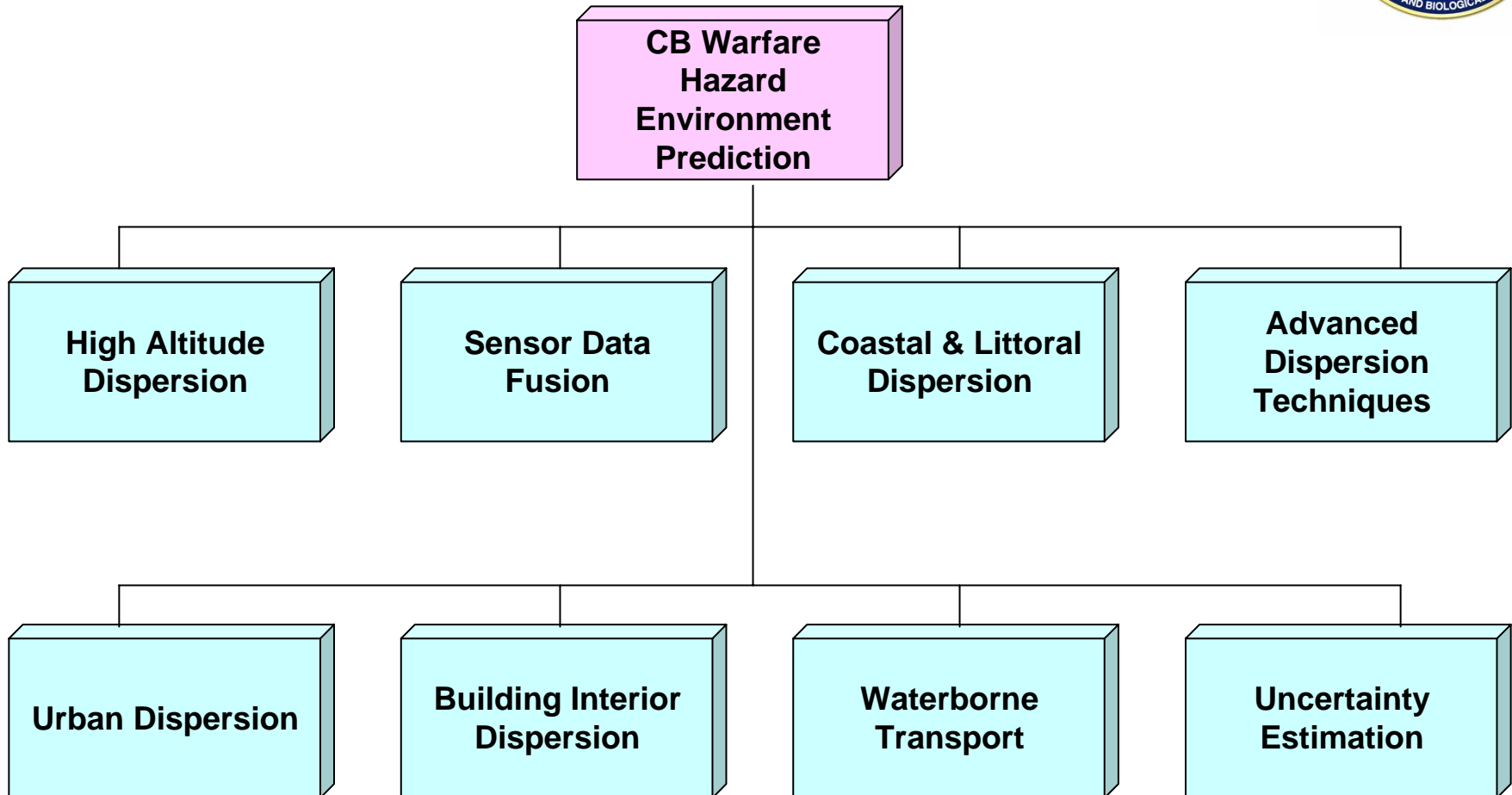# Environmental Hazard Prediction Program Components

- Program management

- Technical guidance and support

- **Model development and acquisition**

- Enabling capability coordination

- Experimental data

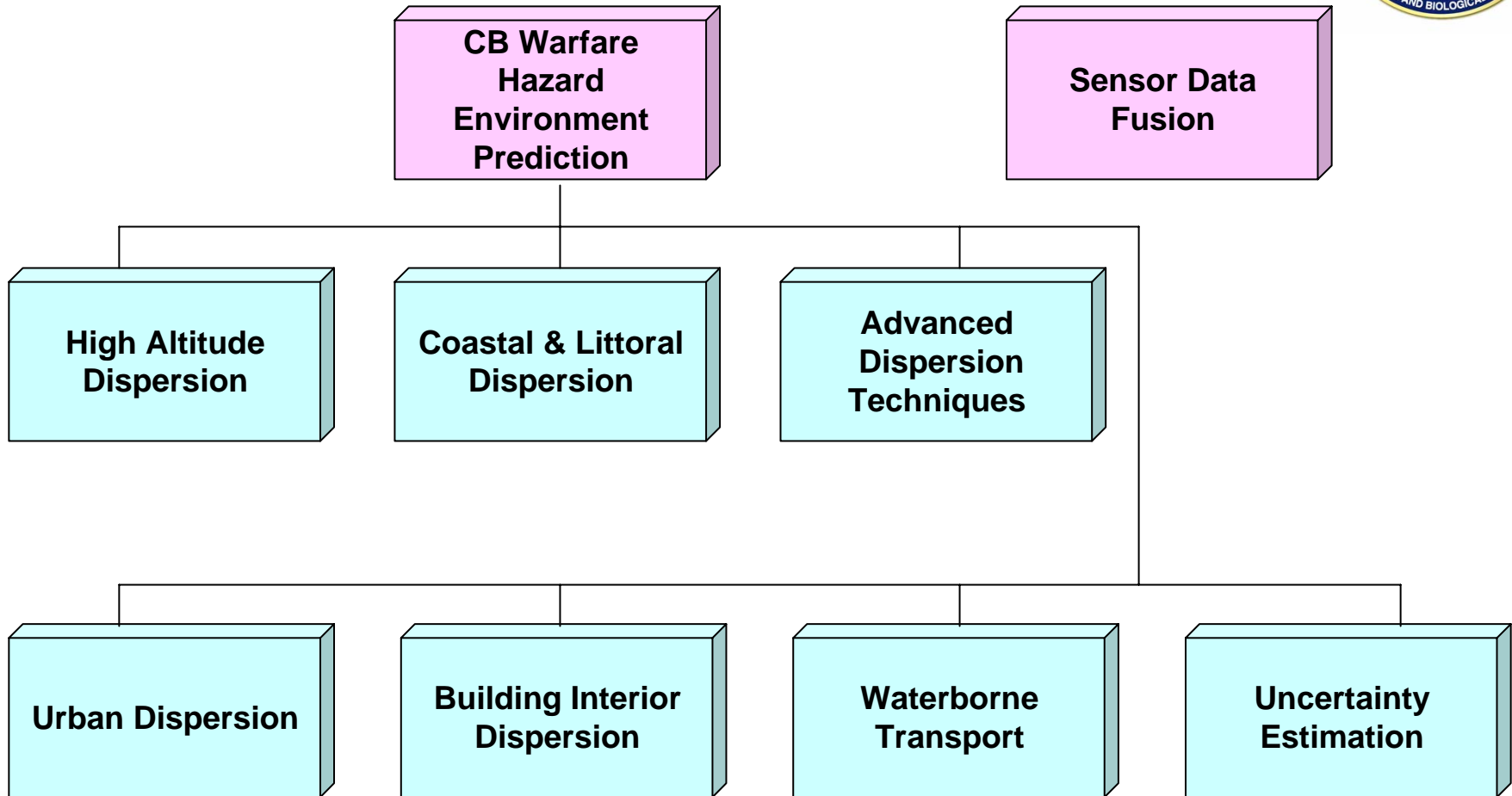- System integration

- Technology transition

CB Warfare Hazard Environment Prediction Thrust Area Focus Areas

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                    ┌─────────────────────┐
                    │     CB Warfare      │
                    │       Hazard        │
                    │    Environment      │
                    │     Prediction      │
                    └─────────────────────┘
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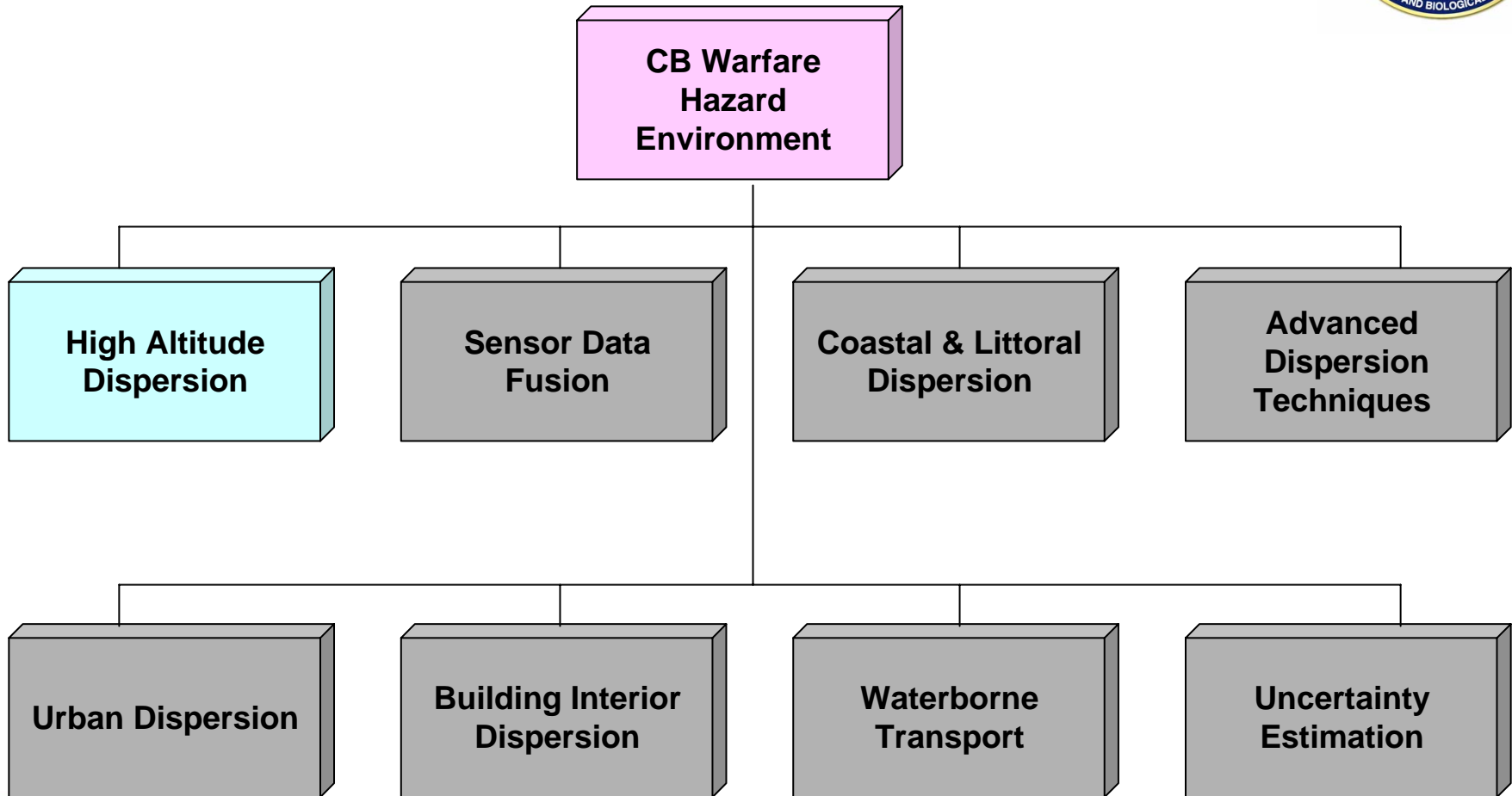
High Altitude Dispersion	Sensor Data Fusion	Coastal & Littoral Dispersion	Advanced Dispersion Techniques

Urban Dispersion	Building Interior Dispersion	Waterborne Transport	Uncertainty Estimation

Future Structure – Split Thrust Area

CB Warfare Hazard Environment Prediction

Sensor Data Fusion

High Altitude Dispersion

Coastal & Littoral Dispersion

Advanced Dispersion Techniques

Urban Dispersion

Building Interior Dispersion

Waterborne Transport

Uncertainty Estimation

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CB Warfare Hazard Environment Prediction Thrust Area Focus Areas

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                        CB Warfare
                        Hazard
                        Environment
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- High Altitude Dispersion
- Sensor Data Fusion
- Coastal & Littoral Dispersion
- Advanced Dispersion Techniques

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- Building Interior Dispersion
- Waterborne Transport
- Uncertainty Estimation

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Missile Intercept Modeling

- JEM Block II requirement
- Very different from modeling in lower atmosphere
  - Thin atmosphere, different turbulence characteristics, uncertainty about behavior and characteristics of released CB materials
  - Lack real-time weather predictions

- Missile intercept source term characterization
  - JSTO is funding program at LLNL/UCSB to address source term specification: *Release and Atmospheric Dispersal of Liquid Agents* (Thursday 1330)

- High-altitude weather
  - JSTO funded project at LLNL to evaluate impact of real-time weather data
    - results show significantly different ground deposition patterns
  - JSTO expects to fund 6.1 project beginning in FY06 to study connection between terrestrial and space weather
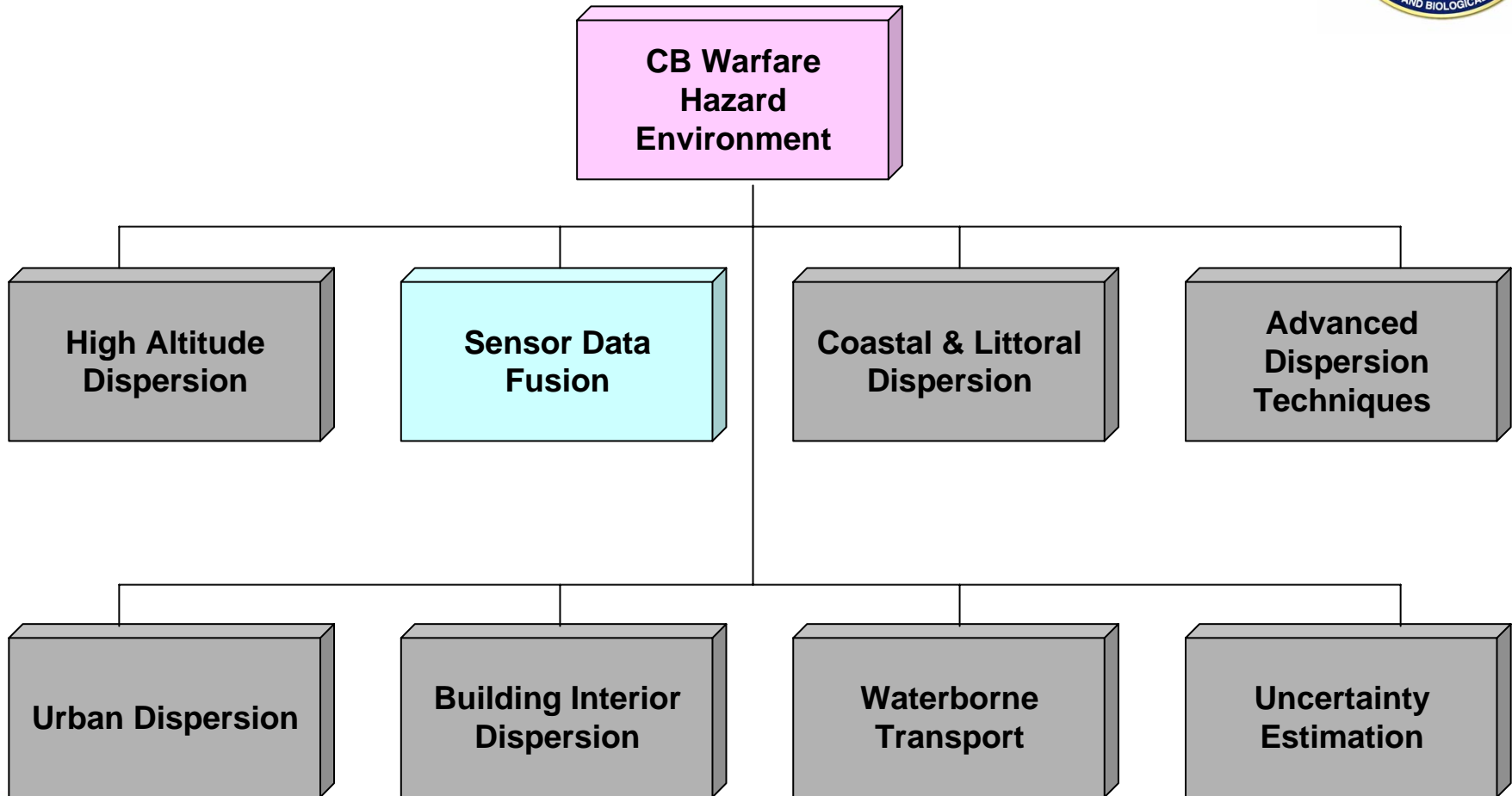
a) 0600 Zulu

East-west 270km

North-south 270km

b) 0700 Zulu

c) 0800 Zulu

d) 0900 Zulu

e) 1000 Zulu

f) 1100 Zulu

deposition modeled with G2S winds

Deposition modeled with climate
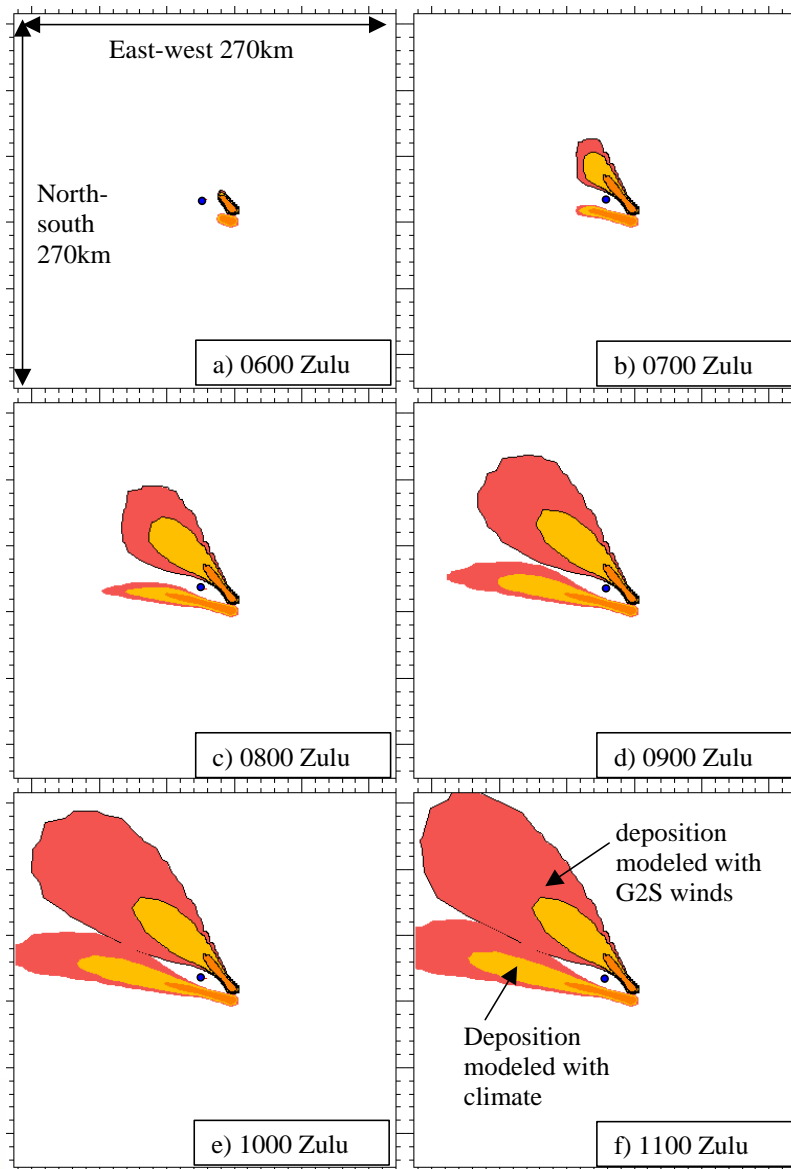
Plan views of deposition contours hourly from 0600 to 1100 Zulu simulated with a US Navy high-altitude meteorological forecast dataset (contours outlined in black), and a US Navy high altitude climatological dataset (no contour outline). The blue dot marks the x-y location of the release point.

CB Warfare Hazard Environment Prediction Thrust Area Focus Areas

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                        CB Warfare
                        Hazard
                        Environment

High Altitude      Sensor Data      Coastal & Littoral    Advanced
Dispersion         Fusion           Dispersion            Dispersion
                                                          Techniques


Urban Dispersion   Building Interior   Waterborne      Uncertainty
                   Dispersion          Transport       Estimation
```

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Sensor Data Fusion

- Large program to improve dispersion modeling
  - Large increase in work projected for FY06
  - Supports both JEM and JWARN
- JSTO program coordinated with TP9/TP10 program
  - Coordinates several related projects, leverages UK programs
- Principle objectives:
  - Blend CB sensor data with dispersion model
  - More accurate depiction of CB hazard area
  - Ability to "backtrack" to source location
  - Provide guidance about sensor performance
  - Support tool to place sensors for facility protection
  - Future: Extend to fusion of meteorological data

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Sensor Data Fusion Presentations

- *Source Term Estimation* (Dstl)
  - Presentation, demo Wednesday 1055-1200
- *Fusion of CB Data and Model Output* (Dstl)
  - Wednesday 1300-1330
- *Chemical/Biological Source Characterization* (DTRA)
  - Wednesday 1330-1400
- *Optimizing Sensor Placement for CB Defense* (NGIT)
  - Wednesday 1400-1430
- *Sensor Location Optimization Tool Set* (ITT)
  - Wednesday 1430-1500
- *Overview of Mesoscale Modeling for Dispersion Applications* (NRL Monterey) – Wednesday 1500-1530

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Additional JSTO Sensor Data Fusion Projects

- Sensor Network Methodologies (NSWC Crane)

- Support to JSTO Sensor Data Fusion Program (NOAA)

- Beginning: Sensor Software Placement Suite (NSWC Dahlgren)

- Beginning: SCIPUFF Adjoint Model for Release Source Location from Observational Data (Aerodyne)

- Beginning: Data Assimilation for Chem-Bio Dispersion in the SCIPUFF/HPAC Computing Environment (UB/PSU) (6.1 project)

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Sensor Data Fusion – Illustration

- Same slides I showed last year – still the best way I have to show how SDF can provide better results than either sensors or models alone

"Model" Results – not perfectly accurate

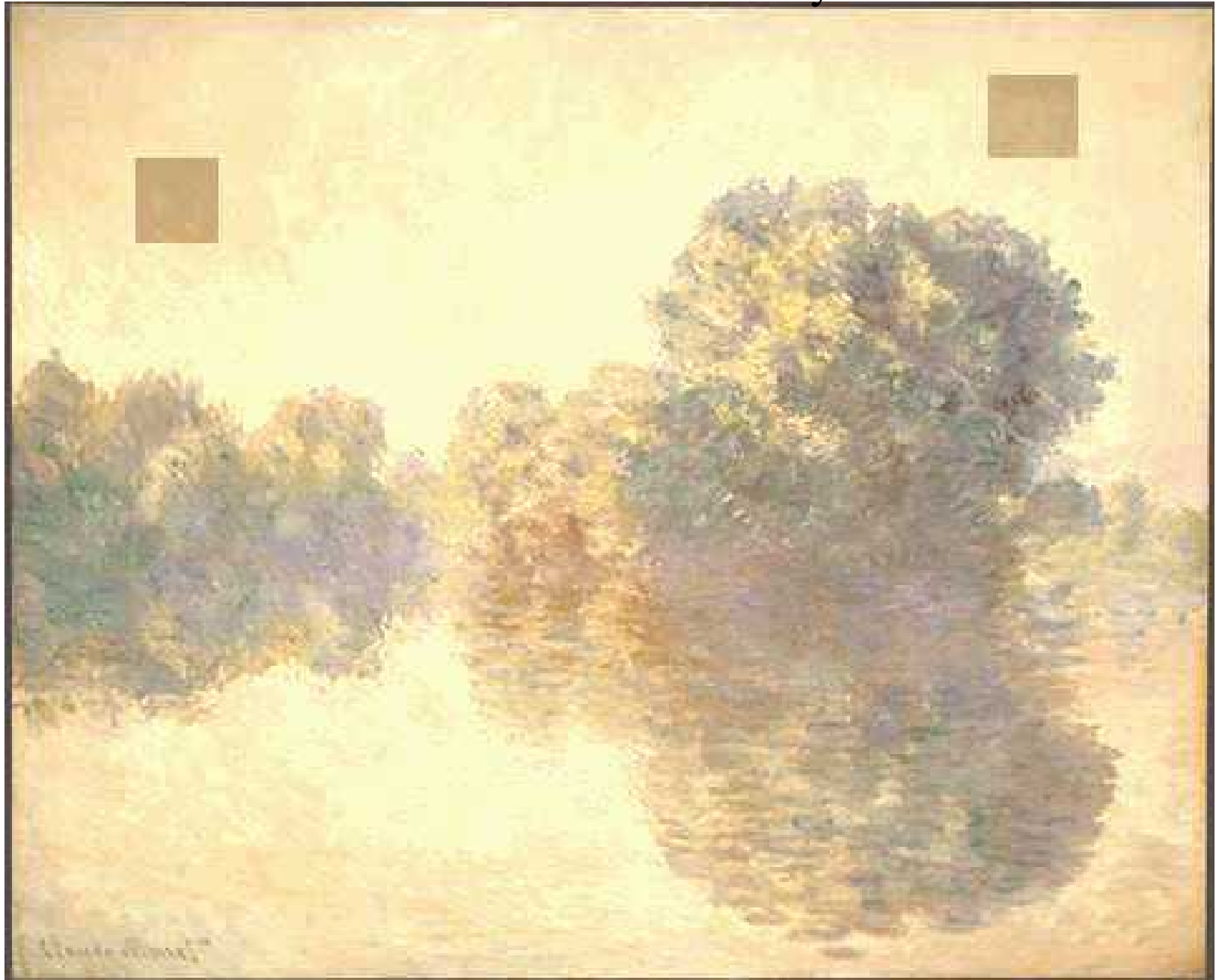# Sensor Data – provide only snapshots of hazard
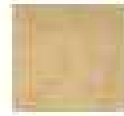
Hazard depiction based on interpolation of sensor data
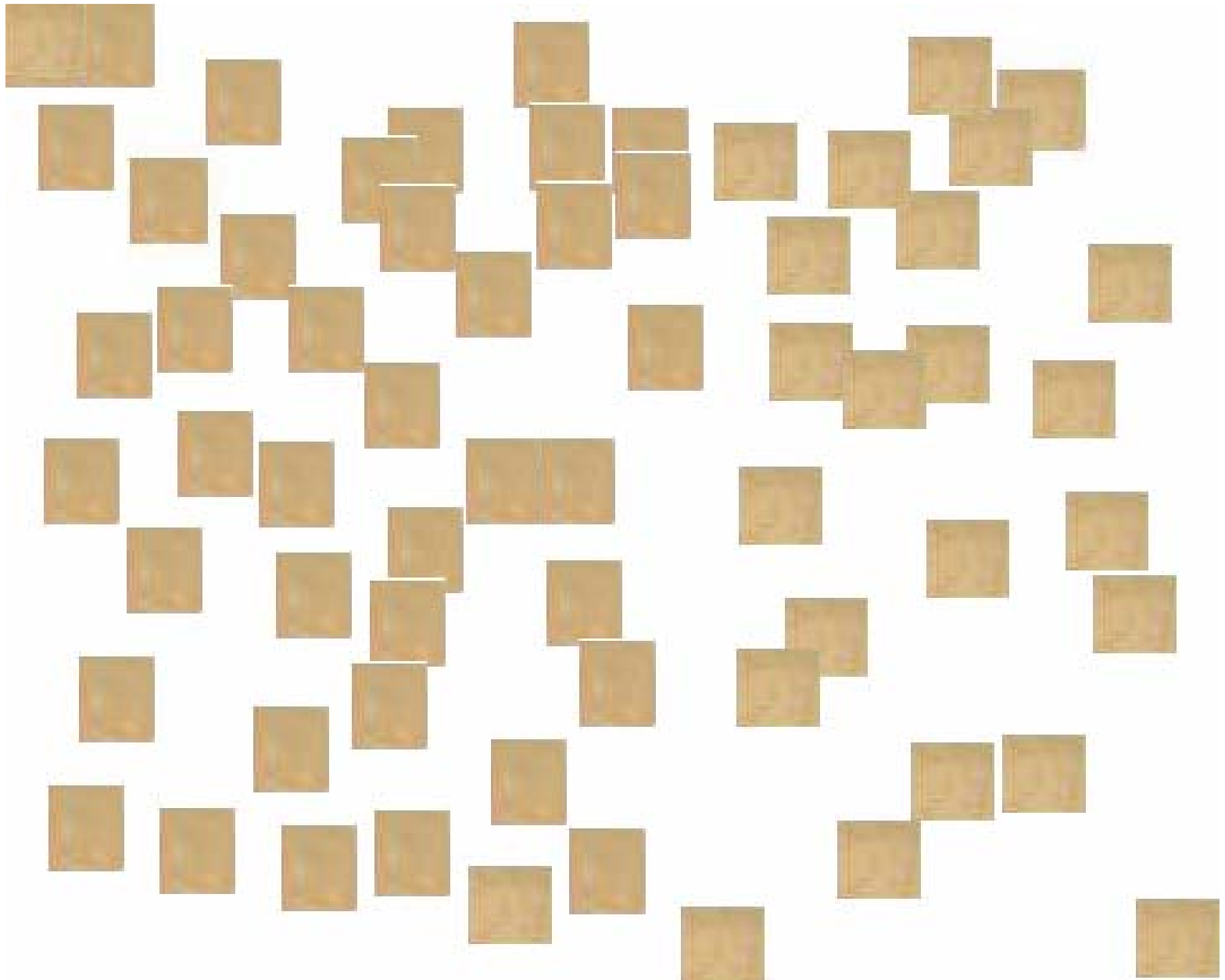
Data fusion? Not really.

Claude Monet

The Seine at Giverny, 1897

**Jackson Pollock**   *Number 1, 1950 (Lavender Mist)*, **1950**

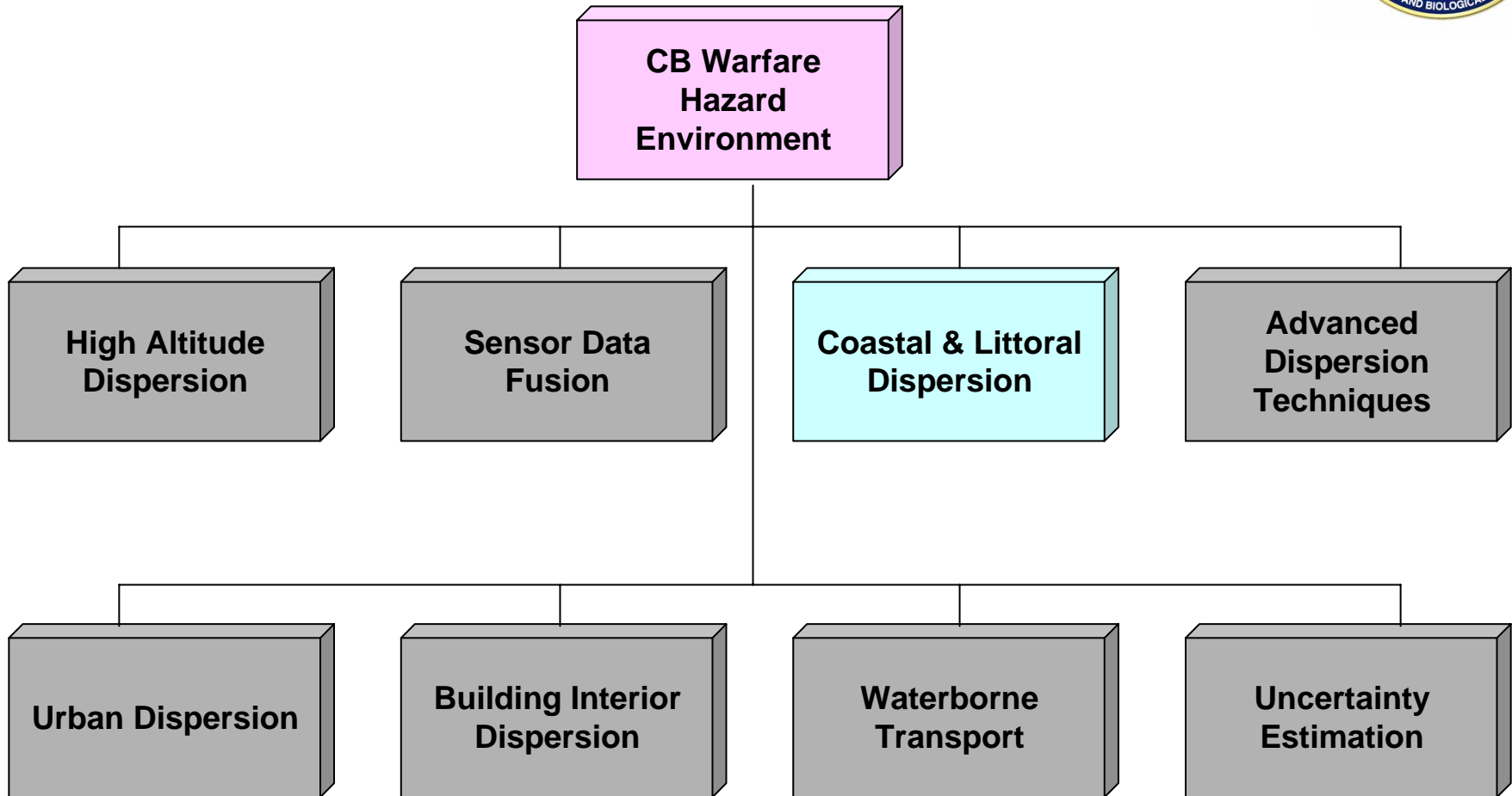(The urban problem will be even more complex)

Prototype Backtracking Capability

- UK developed STEM-II
  - Updates source-term estimates in real-time
  - Robust Bayesian approach
  - Handles real-time chemical sensor data and observer data
  - Demonstration version available
  - Further development required, including
    - Multiple sources
    - Continuous and line releases
    - Biological releases
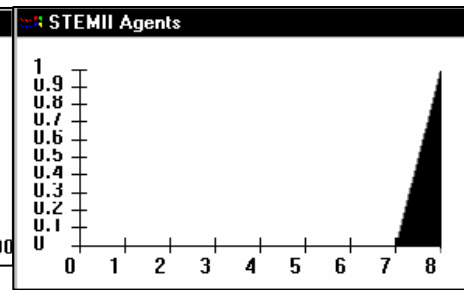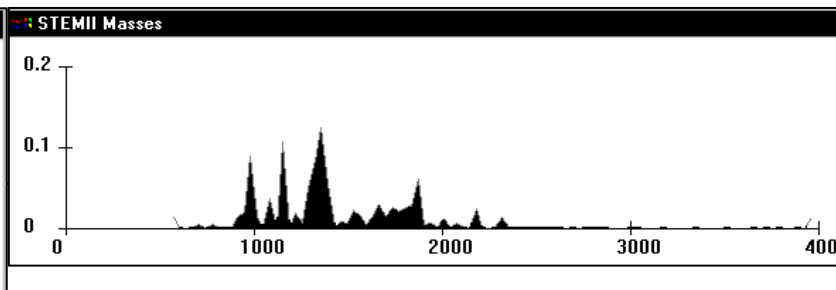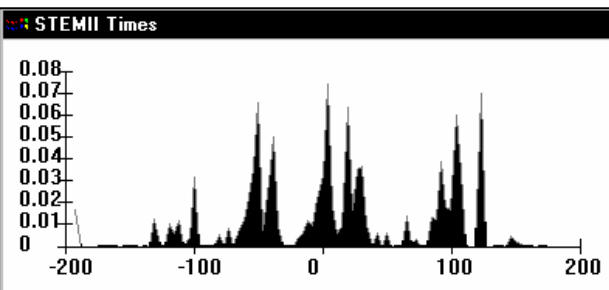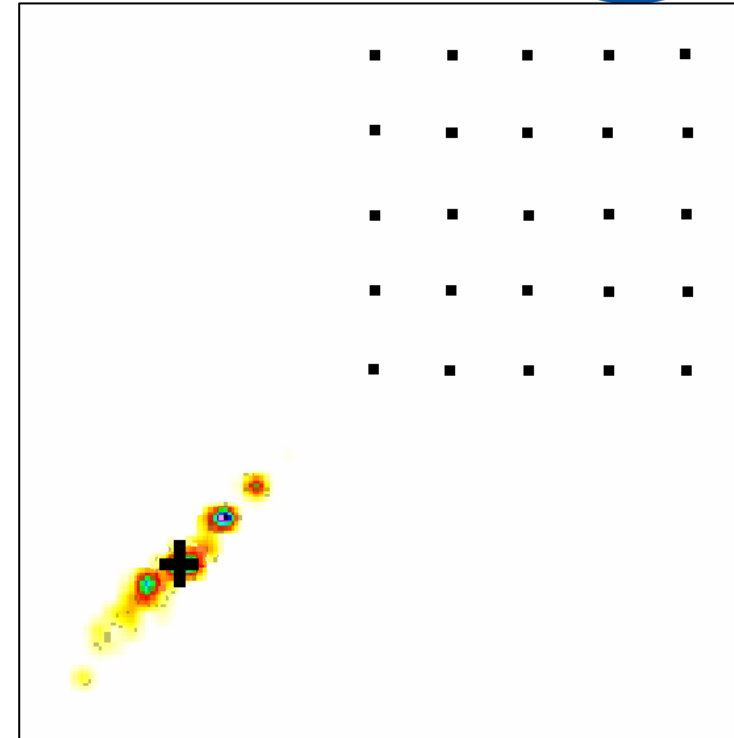
CB Warfare Hazard Environment Prediction Thrust Area Focus Areas

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                    CB Warfare
                    Hazard
                    Environment
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- High Altitude Dispersion
- Sensor Data Fusion
- Coastal & Littoral Dispersion
- Advanced Dispersion Techniques

- Urban Dispersion
- Building Interior Dispersion
- Waterborne Transport
- Uncertainty Estimation

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Coastal and Littoral Improvement

- JEM Block II requirement – also a key problem area
- Identified at least three ways to address this requirement
  - Use high-resolution weather data
  - Develop improved weather modeling and data assimilation systems to use more observations, including radar and other remote sensing, and develop coupled air-sea models
  - Improve boundary layer parameterizations
- JSTO program currently pursuing four C&L initiatives
  - Nowcasting DTO (NRL Monterey) directly relates to this requirement
  - Beginning: *Coupled Air-Sea Modeling for Improved Coastal Urban Dispersion Predictions* (NRL Monterey) (Thursday 1030-1100)
  - Link to radar propagation work, field tests at NSWC, NRL, NPGS. Beginning: *Measurement of Coastal & Littoral Toxic Material Tracer Dispersion* (NSWC Dahlgren) (Thursday 1100-1130)
  - NOAA/Kamada study using AF data from Cape Canaveral to identify sensing systems required for operational improvement, and to evaluate new boundary layer parameterization scheme
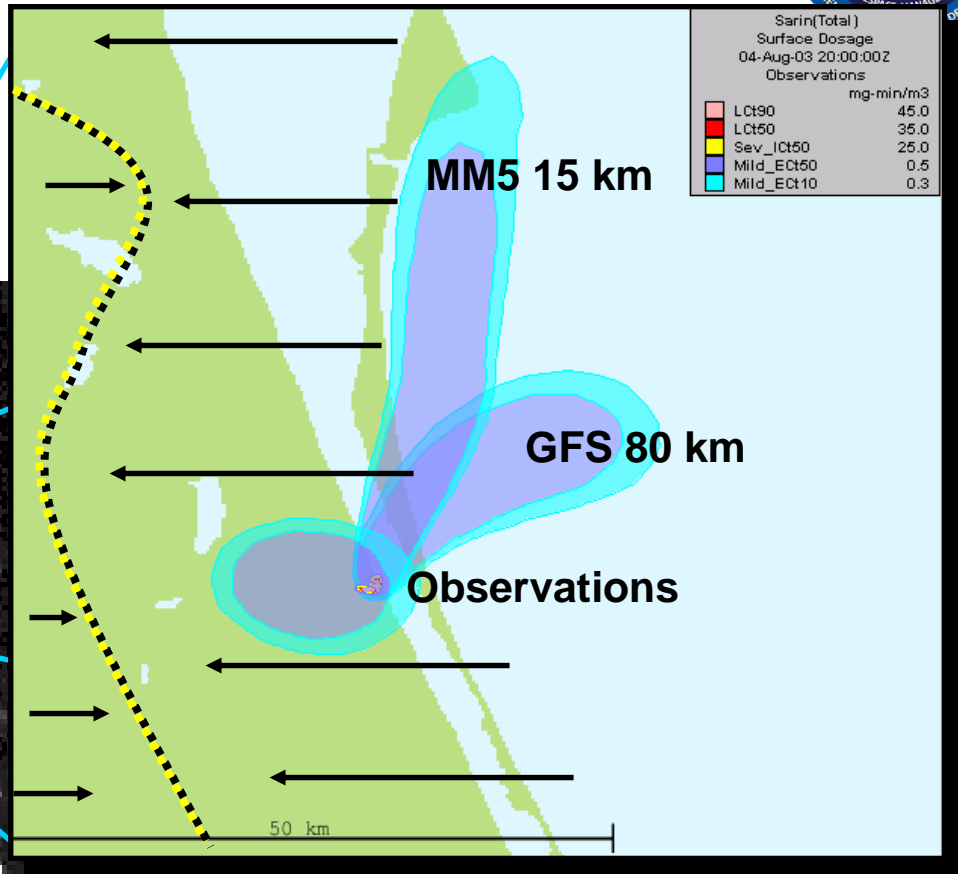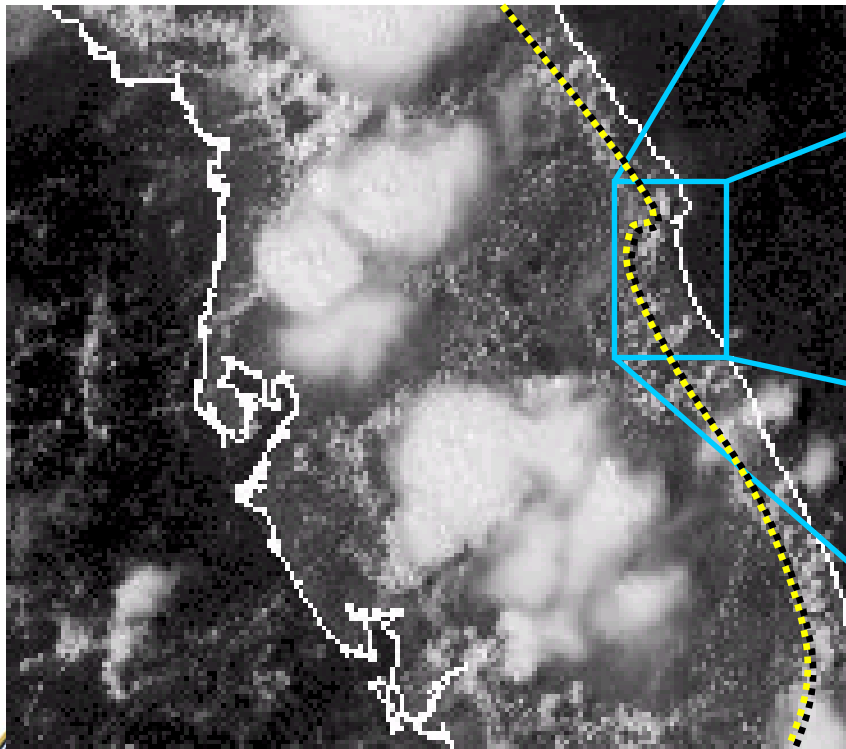
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Weather Model Resolution Effects

Coarse-resolution models unable to resolve the sea breeze circulation

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Illustration of Model Resolution Impact

1000 mb winds over Monterey Bay, CA
27-km COAMPS 21-hr forecast valid 2100Z 25-Aug-97

Santa Cruz

Monterey
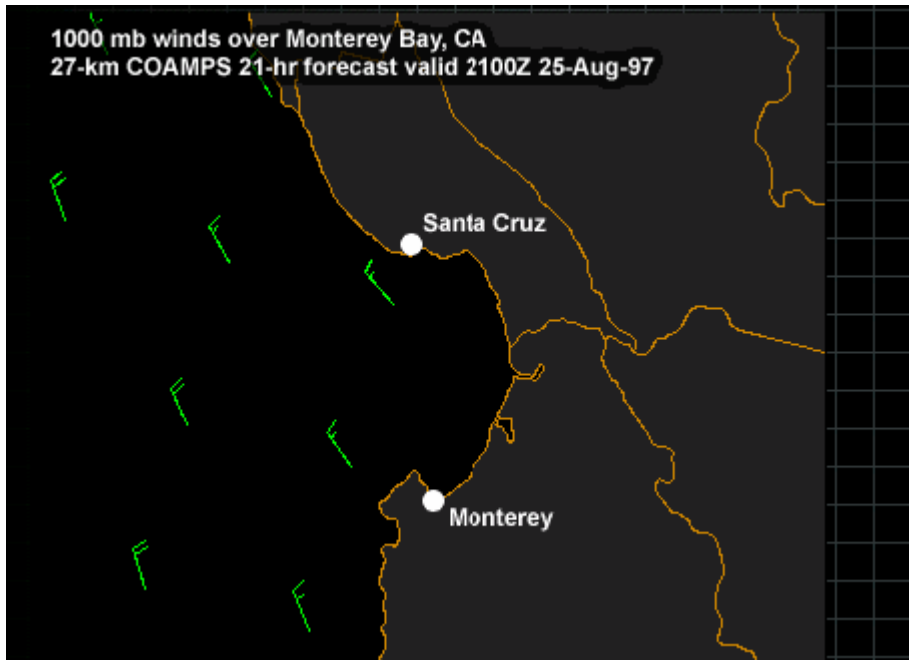
Coarser resolution (27 km) reveals very little detail in the wind field

1000 mb winds over Monterey Bay, CA
3-km COAMPS 21-hr forecast valid 2100Z 25-Aug-97

Santa Cruz

Monterey
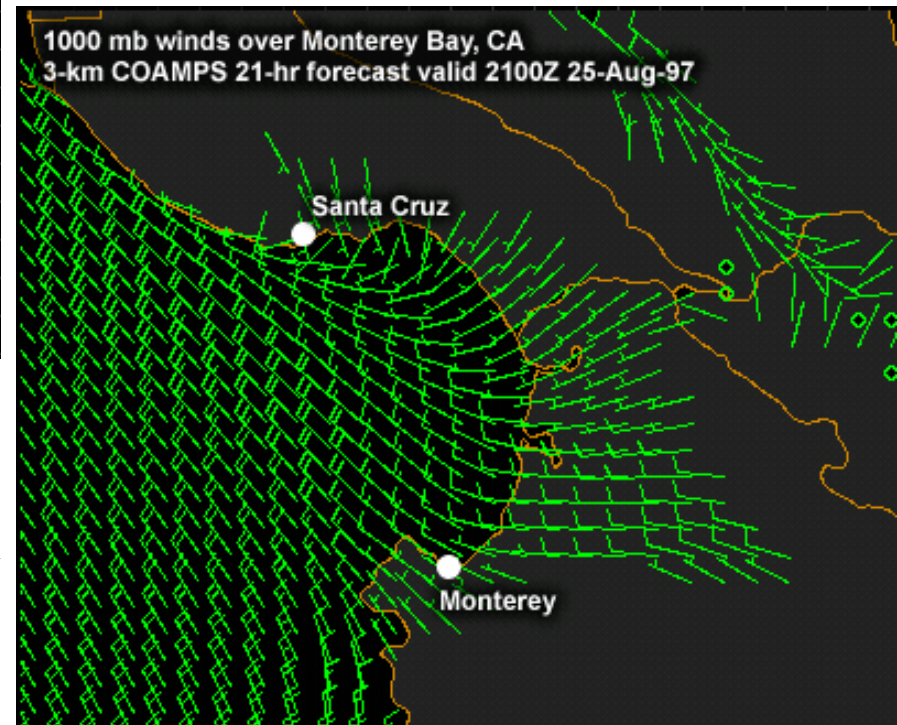
Higher resolution (3 km) reveals onshore flow of the sea breeze

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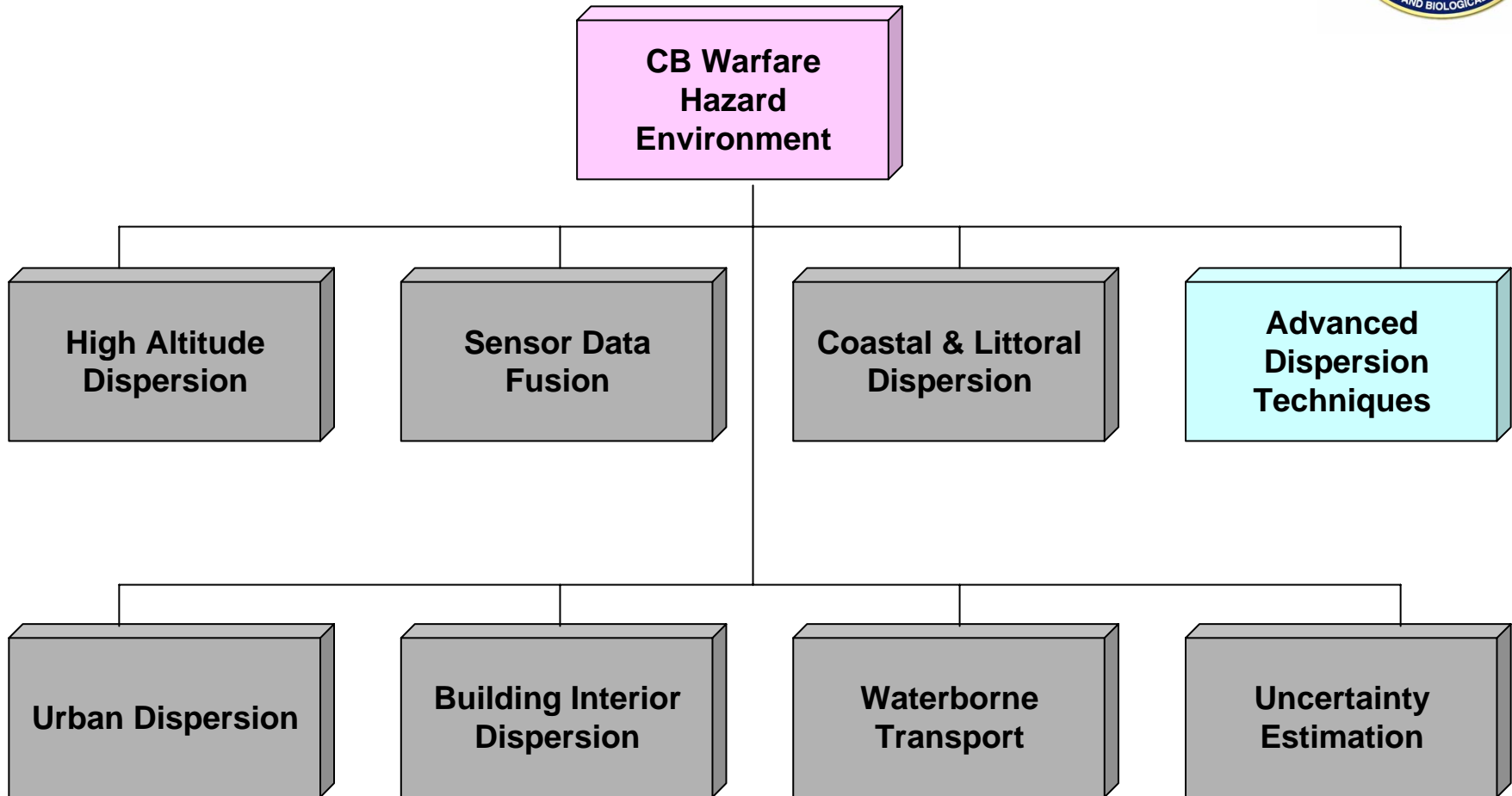
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Improvements in T&D Methodologies

- JEM has Block II requirement to improve T&D methodologies when significant benefits will result
  - Many options: Add new models, improve source term models, improve parameterizations, make better use of weather or land-surface data, etc.
- Current Projects:
  - Developing MESO/RUSTIC as possible future component of JEM: *Chemical and Biological Hazard Environmental Prediction* (NSWC Dahlgren) (Thursday 0900-0930)
  - Supporting R&D in weather data assimilation (NRL Monterey)
- New Projects:
  - 6.1 project with Army Research Lab: Turbulence in the Stable Boundary Layer
  - 6.1 project with NCAR/PSU: Relationship of Boundary Layer Winds to Soil Moisture & Cloud Properties
  - Cellular Automata Exterior Hazard Assessment Tool (NSWC Dahlgren)
  - Modeling the Atmospheric Chemistry of TICs (DTRA)
  - Coastal and Littoral program (discussed earlier)
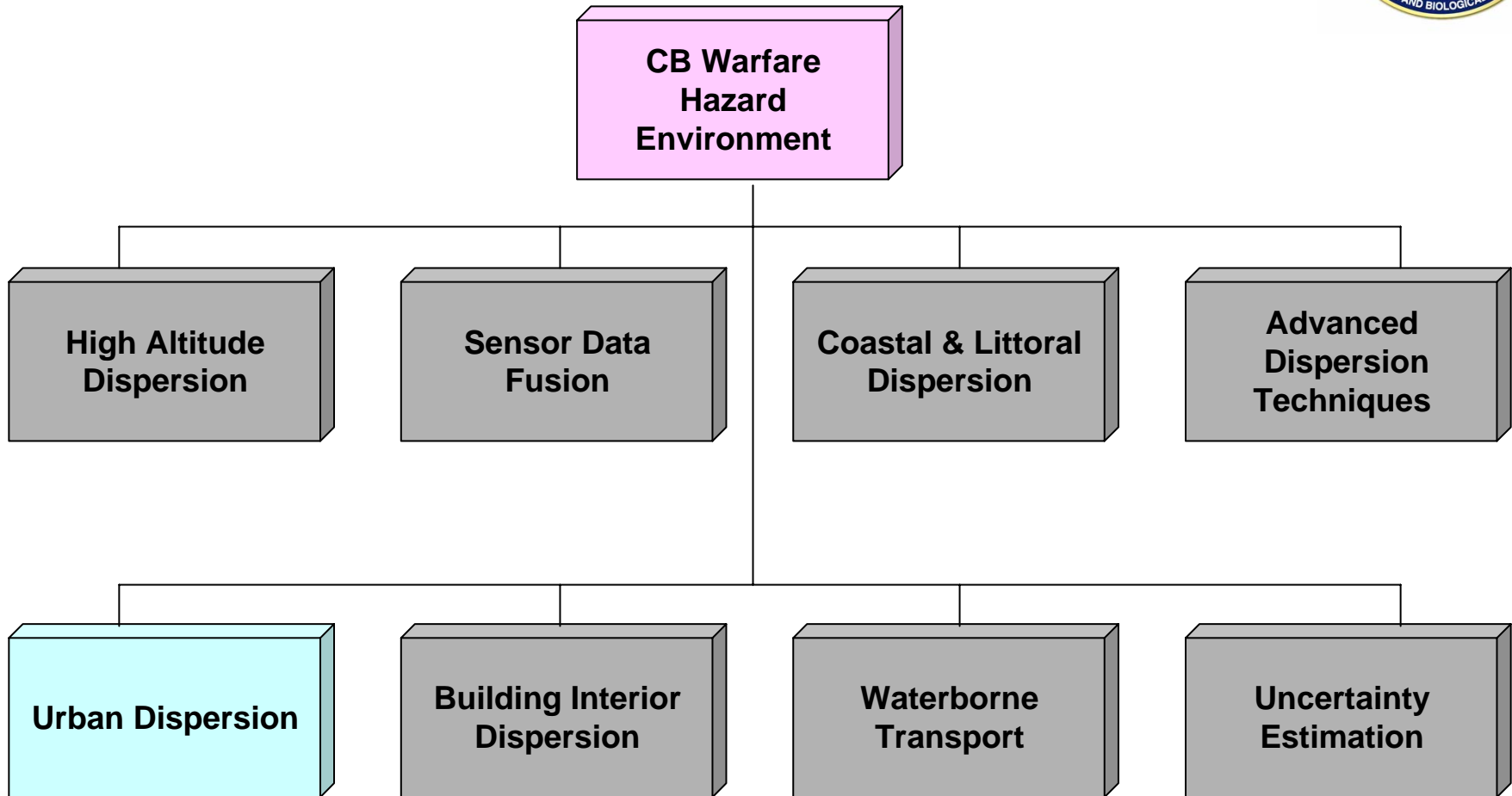
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Urban Dispersion Modeling

- JEM Block II requirement – already many investments elsewhere – relatively little needed by JSTO

- Variety of urban wind and dispersion models available
  - One choice is to link models of difference scales: *Contaminant Transport and Dispersion Modeling in Urban Areas Using Coupled Mesoscale (WRF) and Urban Scale Models (CFD-Urban)* (CFDRC) (Thursday 0930-1000)
  - UWM, UDM integrated into HPAC
  - JSTO is supporting development of MESO/RUSTIC
  - Initial JEM urban models will be selected by JPM-IS
  - Will need ability to predict CB agent concentration and atmospheric pressure on sides of buildings for link to building interior modeling
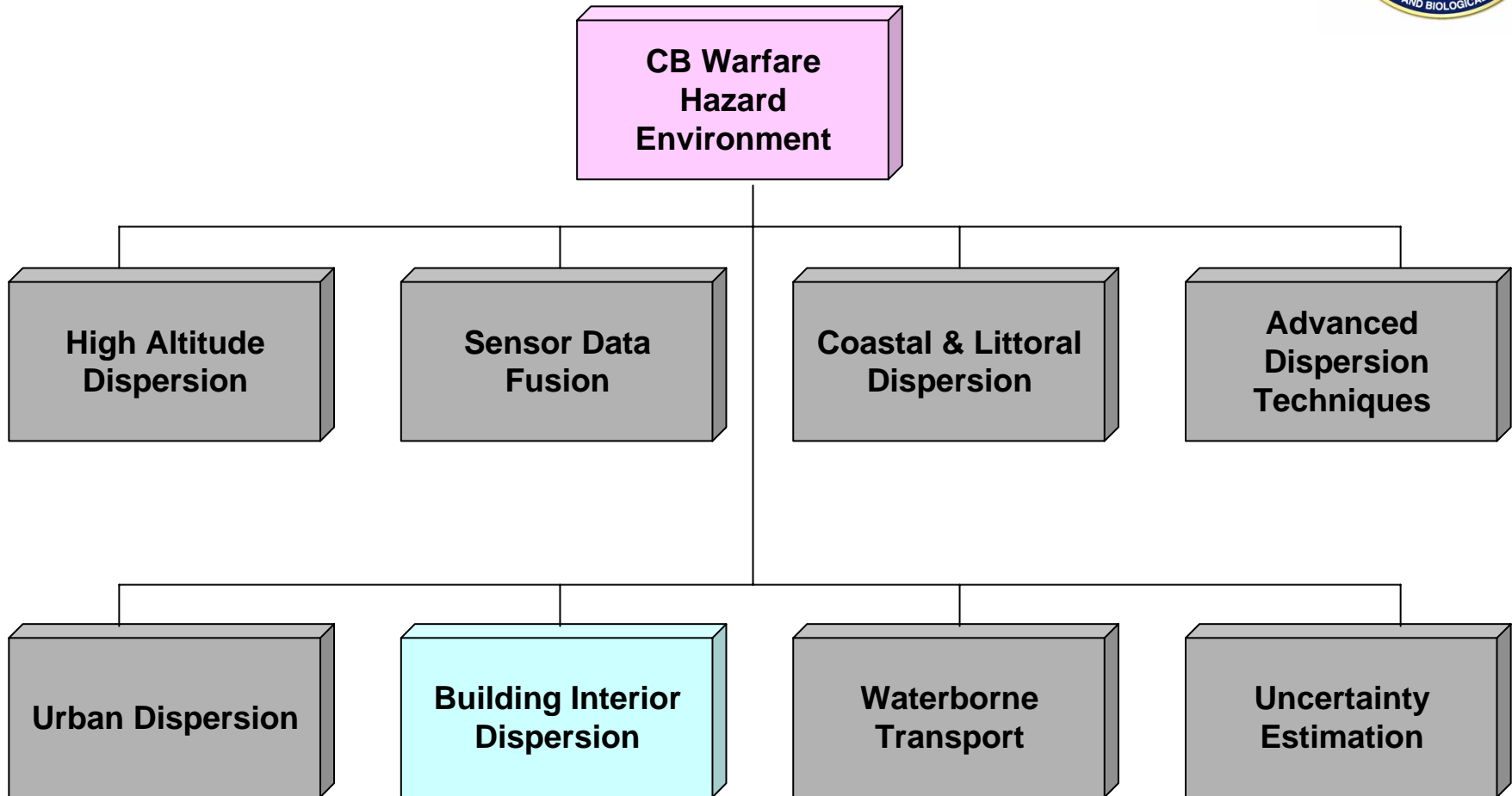
Urban Dispersion Modeling (cont)

- Program Plans
  - Complete DTO developing MESO/RUSTIC
  - Proposed IPT to evaluate use of CFD models by JEM
- New Projects
  - Benchmark for Computational Modeling of Urban Flows (NRL)
  - Rapid Wind & Pressure Calculations Around Buildings (LANL)
- Field Studies
  - Urban 2000, MUST, Joint Urban 2003 datasets in widespread use
  - Considering future field studies
    - May conduct study to collect and use data from Pripyat, Ukraine (near Chernobyl) (Texas Tech)
    - May participate in field study near Helsinki Finland

CB Warfare Hazard Environment Prediction Thrust Area Focus Areas
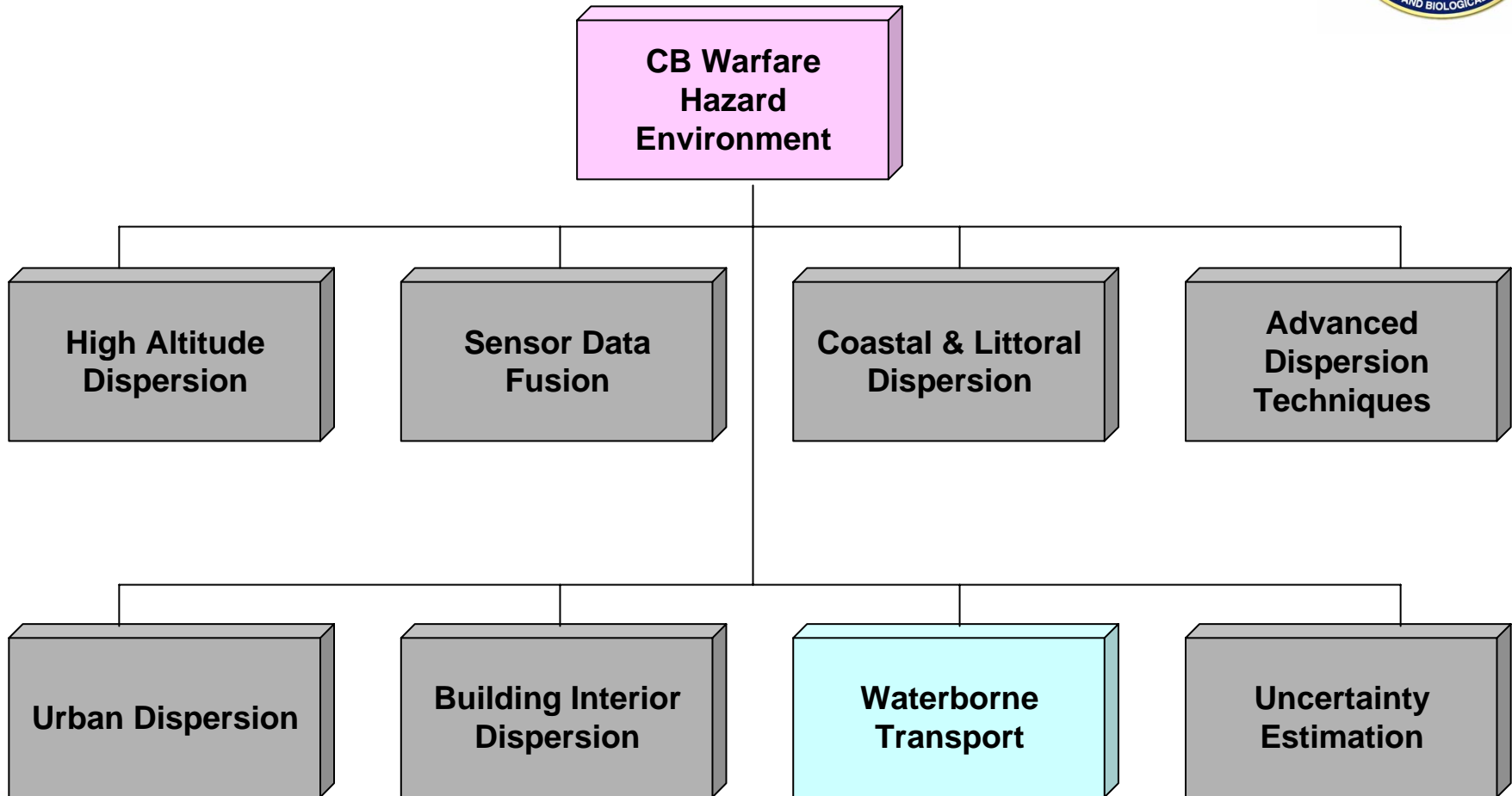
Building Interior Dispersion Modeling

- JEM Block III requirement

- Some models already exist
  - Multi-zonal models (COMIS, CONTAM, MBLM) at LBNL, NIST, DTRA, DARPA, NSWC, SAIC
  - Coarse-grid CFD models for large rooms

- Newer types of models may become available

- Proposal to fund coordination of COMIS and CONTAM into next-generation multi-zonal model
  - Leverage DARPA's Immune Building Program, DTRA's BINEX capability, NSWC and DOE/DHS R&D programs

- Hope to coordinate with DHS
  - DHS making large investment in this area

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CB Warfare Hazard Environment Prediction Thrust Area Focus Areas


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   ┌─────────────┬───────┴───────┬─────────────┐
High Altitude   Sensor Data   Coastal &       Advanced
Dispersion      Fusion        Littoral        Dispersion
                              Dispersion      Techniques

   ┌─────────────┬───────────────┬─────────────┐
Urban           Building Interior  Waterborne   Uncertainty
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DTRA
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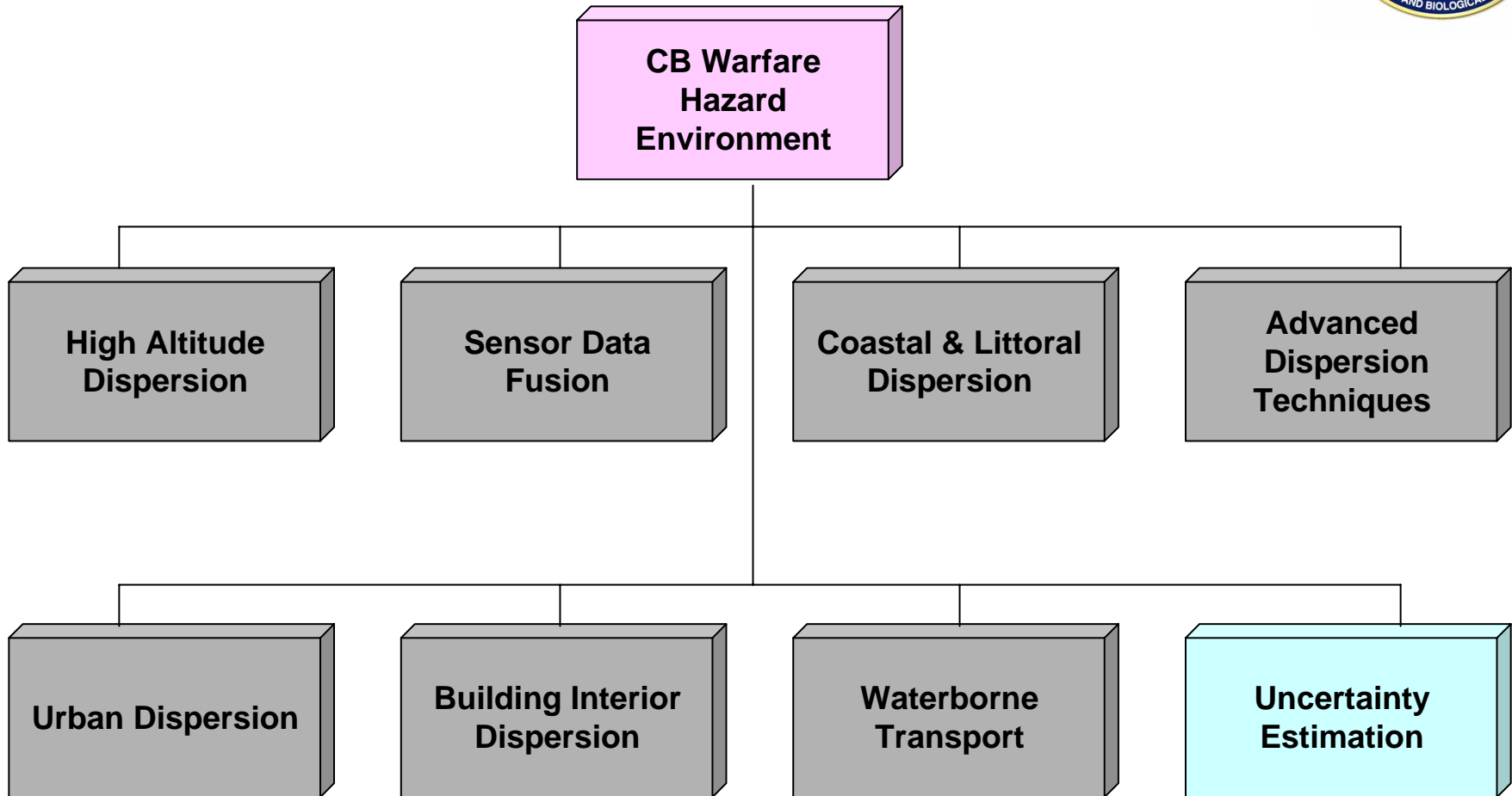
Waterborne Transport Modeling

- JEM Block III requirement

- No active JSTO program in this area now

- Several programs underway elsewhere
  - Navy, ORNL, DTRA, DHS

- JSTO will watch other work and develop programs as needed

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Uncertainty Estimation

- No active JSTO program in this area now

Performing Organizations

- Previous: NSWC Dahlgren, NRL Monterey, ITT

- Current: NSWC Dahlgren, NRL Monterey, ITT, DTRA, LLNL, UCSB, Dstl, NOAA, NSWC Crane

- Imminent (planned): NSWC Dahlgren, NRL Monterey, ITT, DTRA, LLNL, UCSB, Dstl, NOAA, NSWC Crane, NRL DC, NGIT, NASA, ARL, UB, PSU, NCAR, Aerodyne

- Possible Future: NSWC Dahlgren, NRL Monterey, ITT, DTRA, LLNL, UCSB, Dstl, NOAA, NSWC Crane, NRL DC, NGIT, NASA, ARL, UB, PSU, NCAR, Aerodyne, CFDRC, Titan, ARIA, LBNL, NPS, DPG, DRDC, NIST, DARPA, NASA, AFWA, Titan, ORNL, SAIC, DSTO, TTU, Vaisala…?

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Summary

- Established comprehensive program to meet requirements, address weak areas, coordinate activities

- Brings S&T program into line with coordinated, unified model development programs

- Expect to see areas of particular expertise developed at DoD labs, R&D activities

- EPP budget increase provided opportunity to develop comprehensive, coordinated program

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