Atmospheric dispersion modelling in support of civil emergency operations

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Civil emergency operations

- General framework for handling risk:
  - Prior to any emergency:
    - Comprehensive assessment of risk;
    - Implementation of risk mitigation measures.
  - In the event of an emergency:
    - Trained capability for “timely intervention”.
- What does this framework mean in the case of civil emergencies involving the atmospheric dispersion of chemical or biological (CB) warfare agents?

Atmospheric dispersion modelling

- Atmospheric dispersion is a complex process, involving:
  - **A variety of weather conditions**;
  - A variety of sources;
  - A variety of environments;
  - A variety of analytical methods;
  - A variety of impacts and responses.
- This complexity means that the operational response must be fundamentally expert-based.
  - However, the human capability can be usefully reinforced by the provision of appropriate computational tools.
  - Models are tools for the experts.

Smoke plumes and stability classes

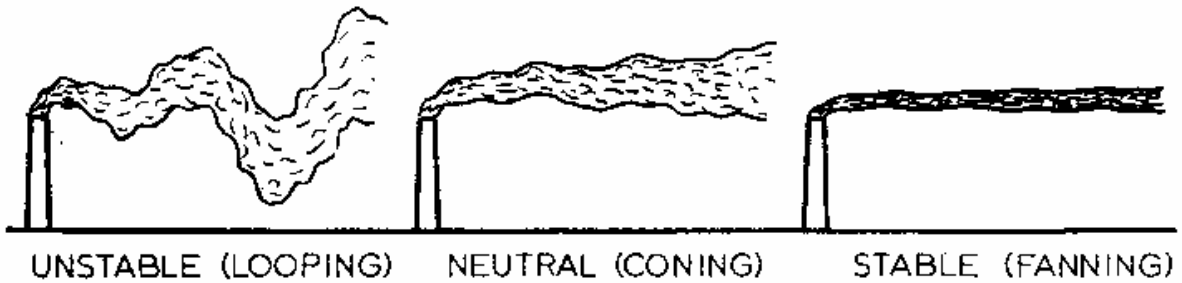
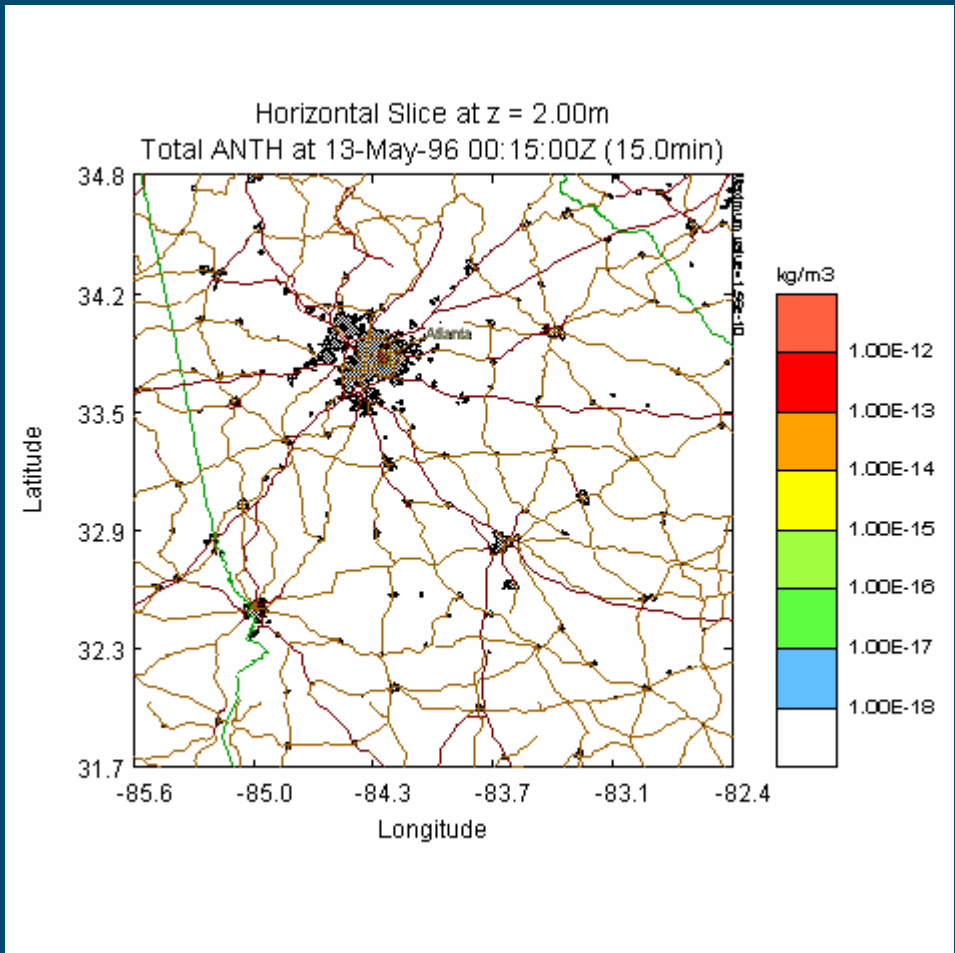


FIG. 5.2 Characteristic forms of smoke-plumes from chimneys. (Church, 1949, and United States Weather Bureau, 1955)

Ref: Frank Pasquill, *Atmospheric Diffusion*, van Nostrand (London, 1962)

Effect of wind variation



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The CBW spectrum illustrates the range of materials that could be used as CBW agents

Toxic industrial chemicals (TICS)	Major CW agents	Emerging CW agents	Mid spectrum agents	BW agents	Genetically modified BW agents
HCN Phosgene chlorine ammonia	**vesicants** **nerve agents** psycho-chemicals	developments from pharmaceutical & pesticide research	**toxins** bioregulators	**bacteria** **rickettsia** **viruses**	**bacteria** **rickettsia** **viruses**
synthetic chemicals			**agents of biological origin**		
				self-replicating	

increasing potency (up to ~10^{12})

CB hazard source terms

- Instantaneous or continuous; ground-level or elevated?
  - Point, line, area or volume source?
- Solid, liquid or gas; particulate, aerosol or vapour?
- Combusting, reacting, decaying, or inert?
- Heavier or lighter than air?
- Hotter or colder than air?
- Deposition, washout, resuspension?

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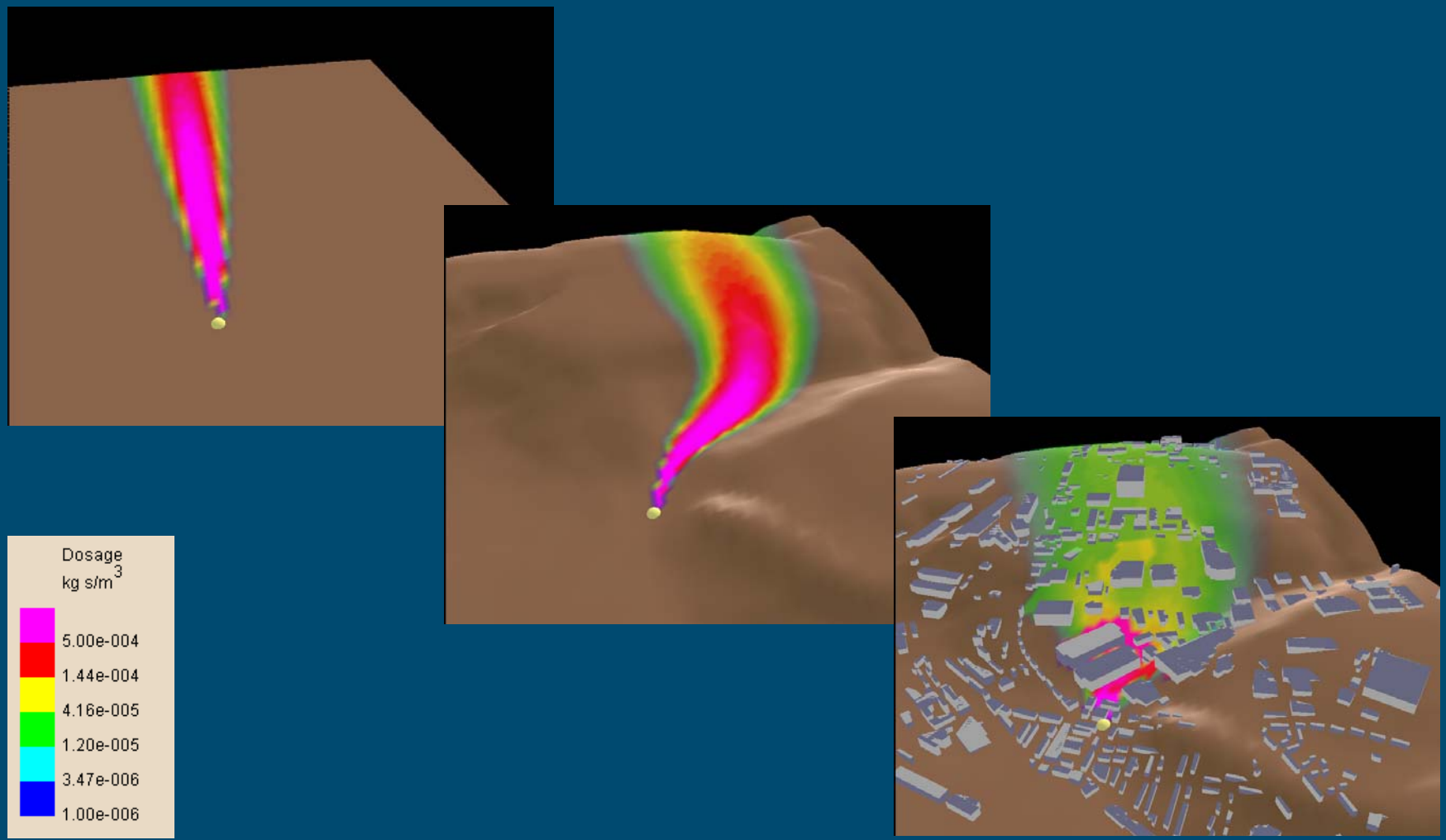
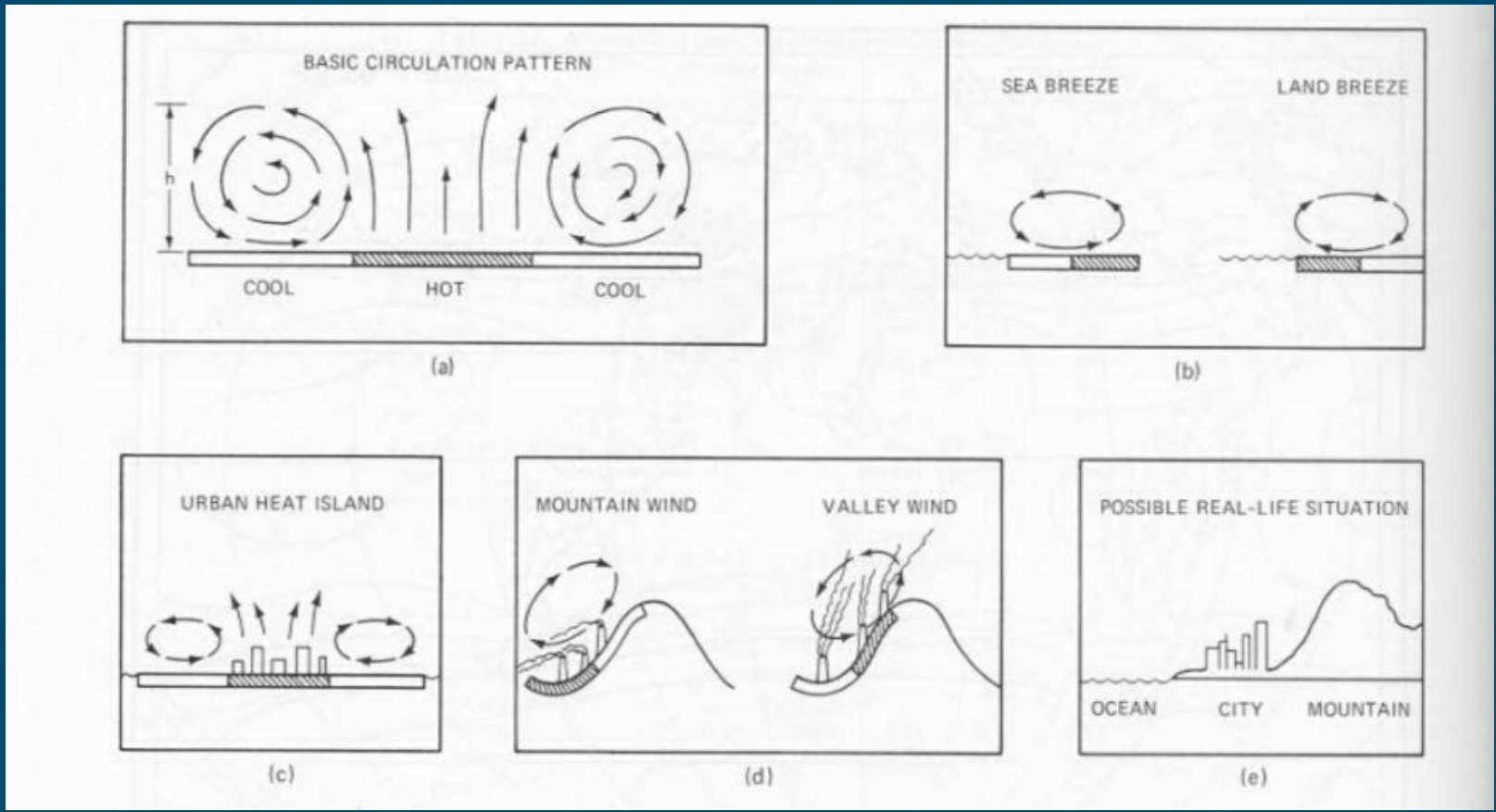
Dispersion environments



Modification of dispersion: Mesoscale terrain effects



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CB impacts

- Death, incapacitation, exposure or infection
  - Incapacitation: myosis, choking, vomiting, irritation, blistering, spasms, paralysis, disorientation, hallucination...
- Taking effect through the lungs, eyes, nose or skin
- Peak concentration or accumulated dose?

UK policy areas for defence against use of CB agents

- Arms control
- Preventing supply
- Deterring against use
- Defending against use
  - Detection, identification and monitoring
  - Warning and reporting
  - Physical protection
  - Hazard management
  - Medical countermeasures and support

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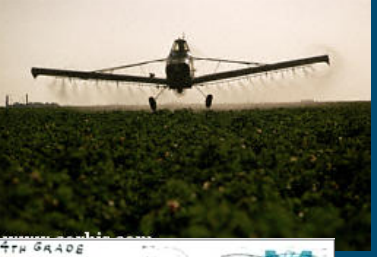


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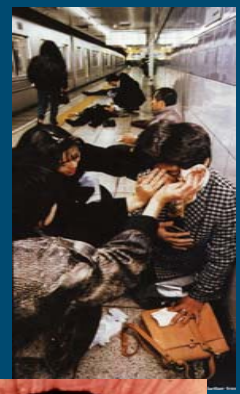



BATS

Current implementation

- Operational modelling support to major events:
  - 2000 Sydney Olympics;
  - 2001 US Presidential Inauguration;
  - 2002 Salt Lake City Winter Olympics.
  - 2004 Athens Olympics - Dstl Tools Used
- During emergency

System Approach to Hazard Modelling

- Modelling and Simulation approaches could be used to support civil emergency applications.
- Dstl have produced a CB synthetic environment
  - has been used in military experimentation
- a CB event is the same for civil as well as military
- Could stimulate civil response systems
  - testing of civil response systems
  - emergency planning

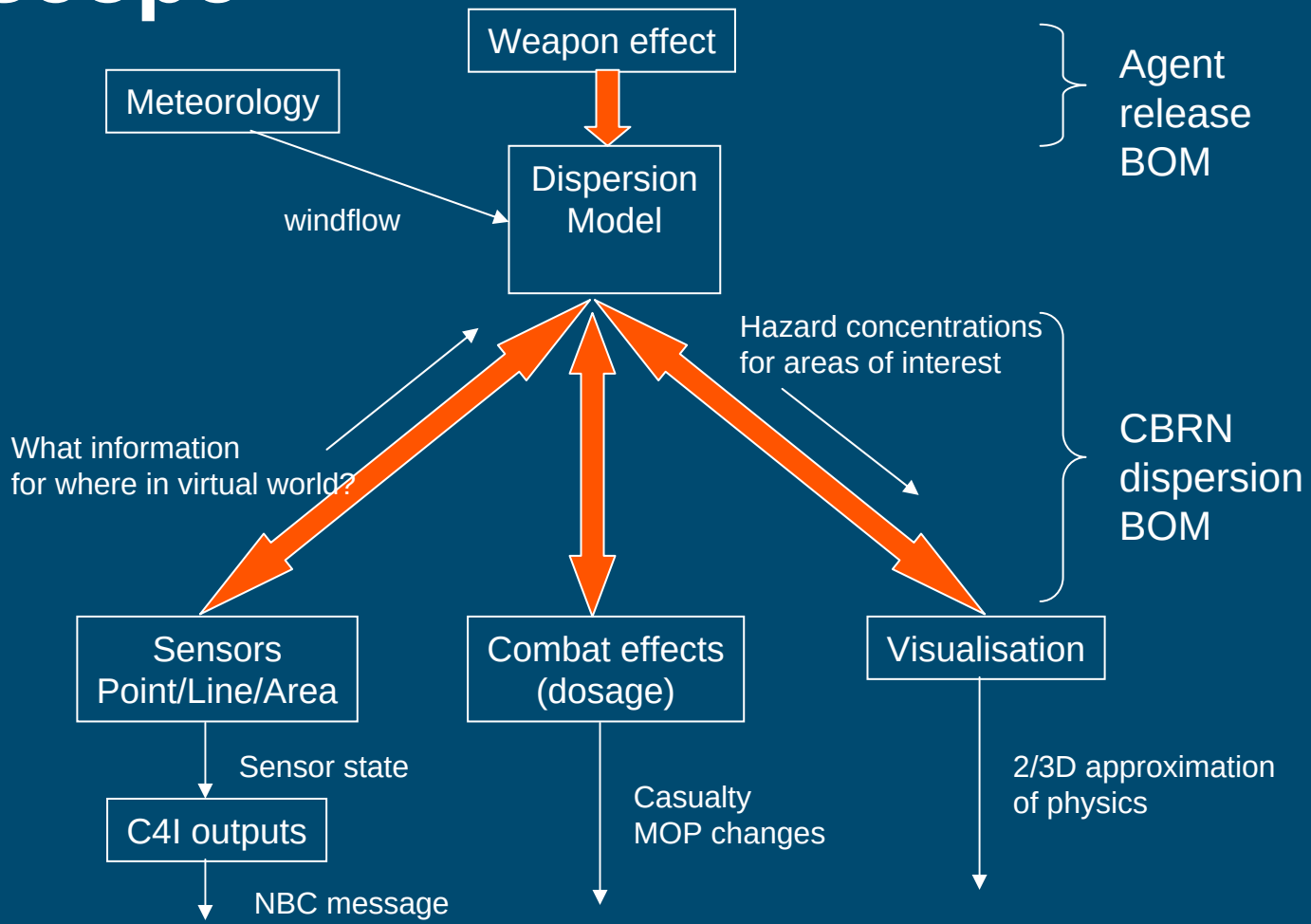
Aims for HLA hazard modelling

- Support physics-based or simplistic source/sensor models
  - concisely handle simple/complicated sensor requests
- Protocols suited to variety of input/dispersion model
- Enormous complexity in atmospheric dispersion
  - Each simulation could use range of different representations - finite difference, finite element, gaussian puff etc.
- Sensors should not need to know complete ground-truth
  - could trigger on variety of agents/particle sizes etc.

Approach to HLA representation

- Uses BOMs
  - WMD hazards are not studied in isolation
- Two separate BOM sets dealing with
  - the releases of agents
  - transportation of hazard to:
    - sensors and detectors
    - other affected simulated entities
  - visualisation of the hazard
- How can we define the best representation in the BOMs?

BOM scope



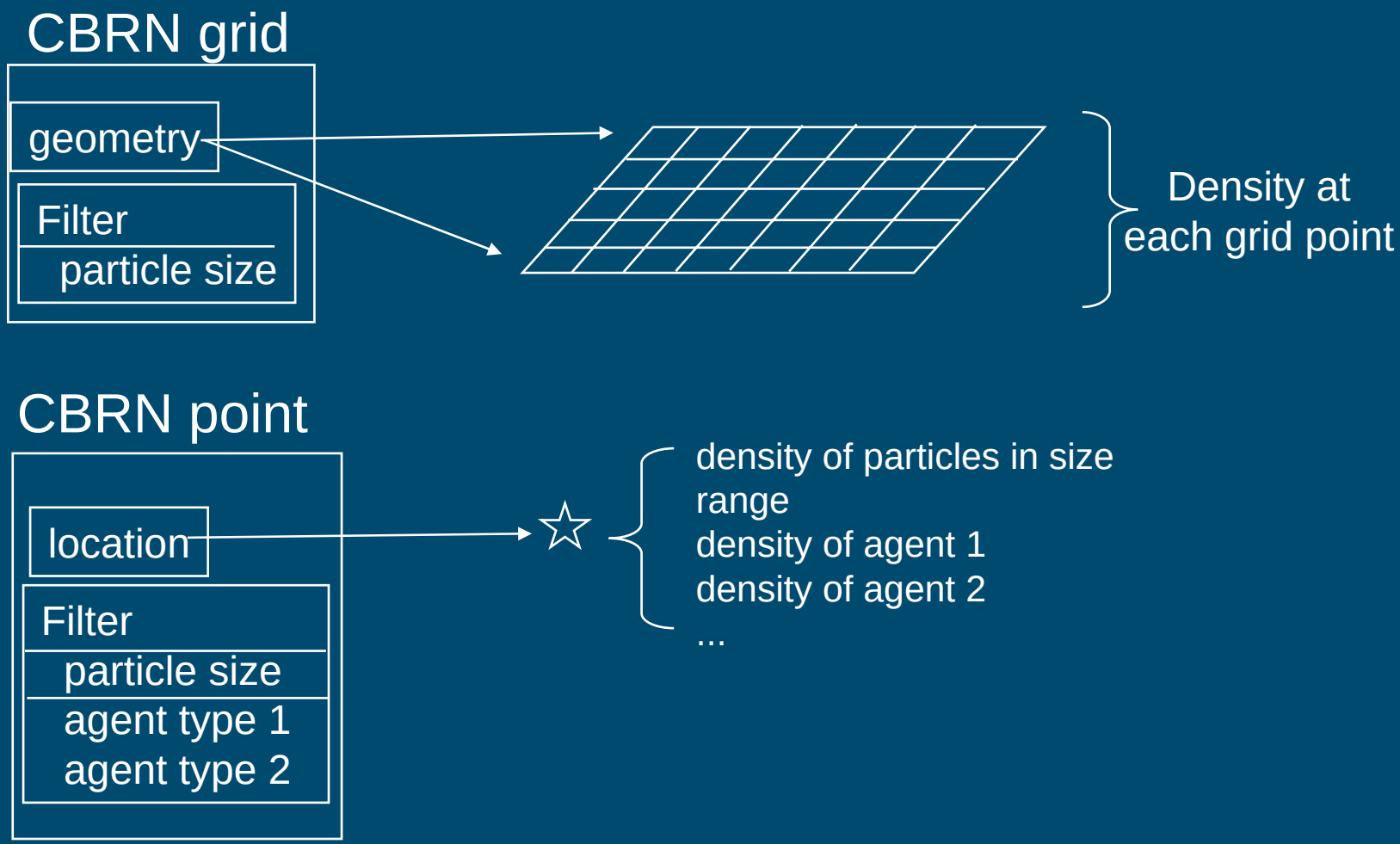
BOM design

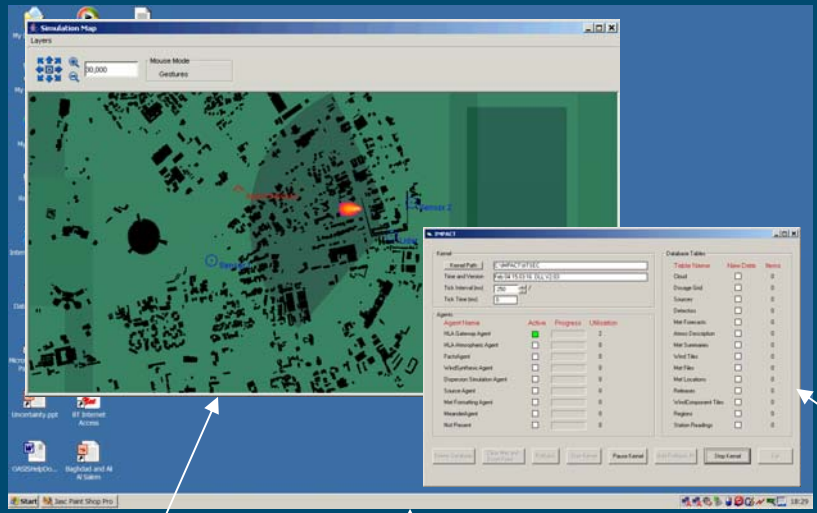
- How does the hazard get distributed by HLA
  - a) the whole environment gets published (like wind)
  - b) the sensor registers its interest & gets a subset
- We chose b) because
  - the size of the environment versus number of sensors
  - dramatically reduces network bandwidth
  - not tied to an inappropriate network representation

Outline of the BOMs

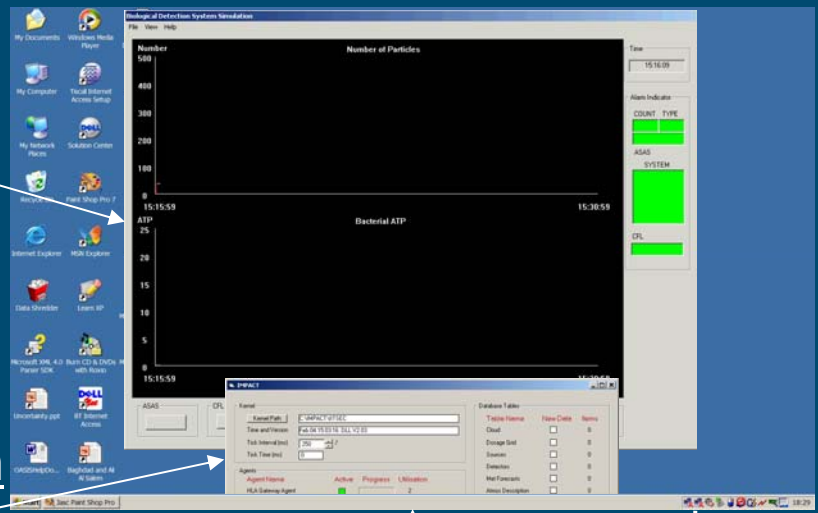
- Spatial classes
  - point, linear and area (grid) values
- Filter object
  - allows sensor to describe its interest in different ways
    - by type
    - by particle size
    - by radioactivity
  - specifying filters allows the dispersion model to combine values and thereby reduce bandwidth

Using the Sensor object BOM





BDS Model



Calculation Engine

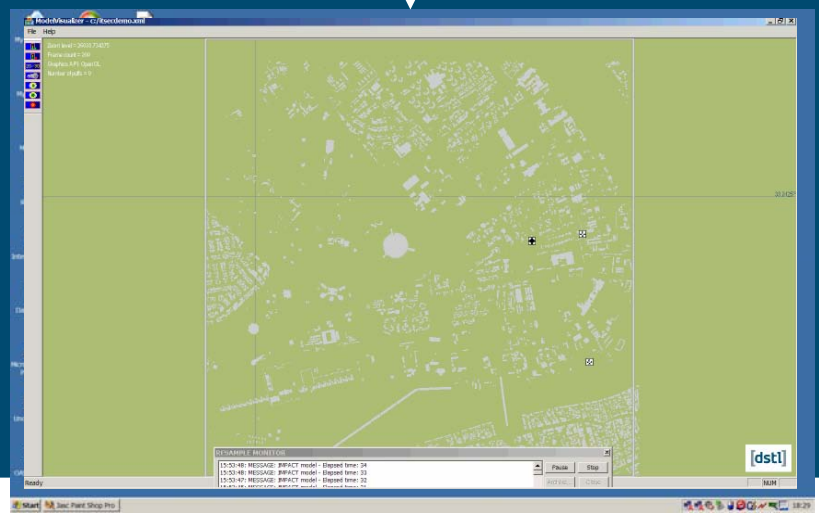
Lidar Model

Network (HLA RTI)

Database

DTRA's WALTS

3rd party chem sensor models



GUI

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