Combined Outdoor-Indoor Dispersion Modelling in Urban Areas

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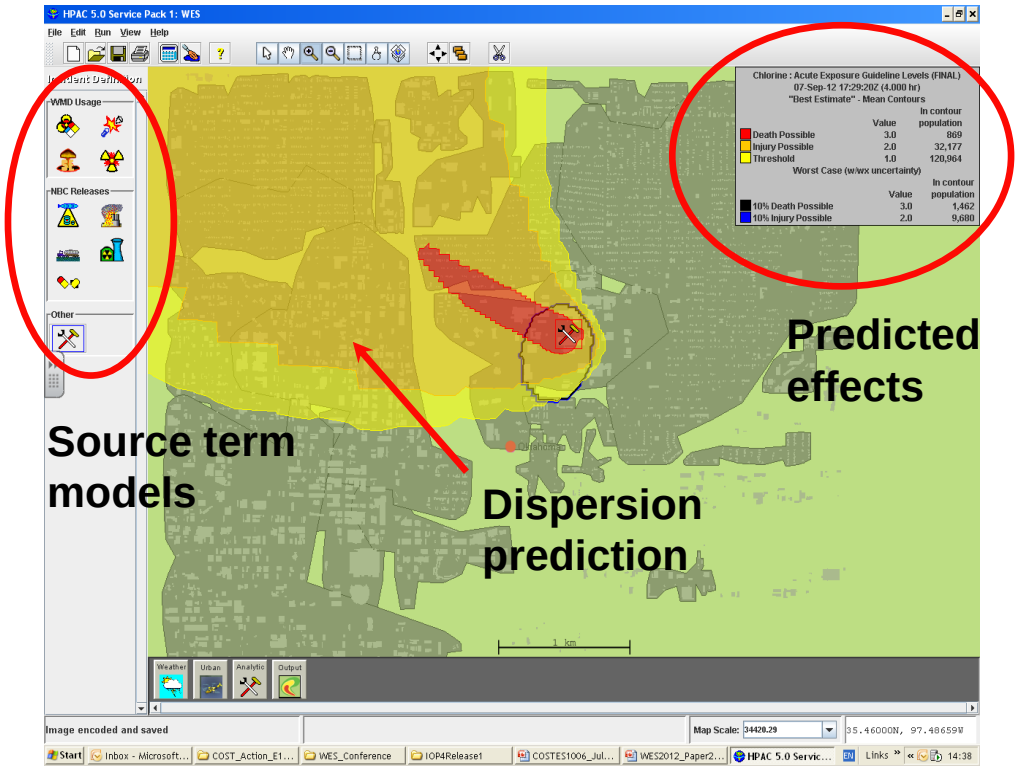
Background

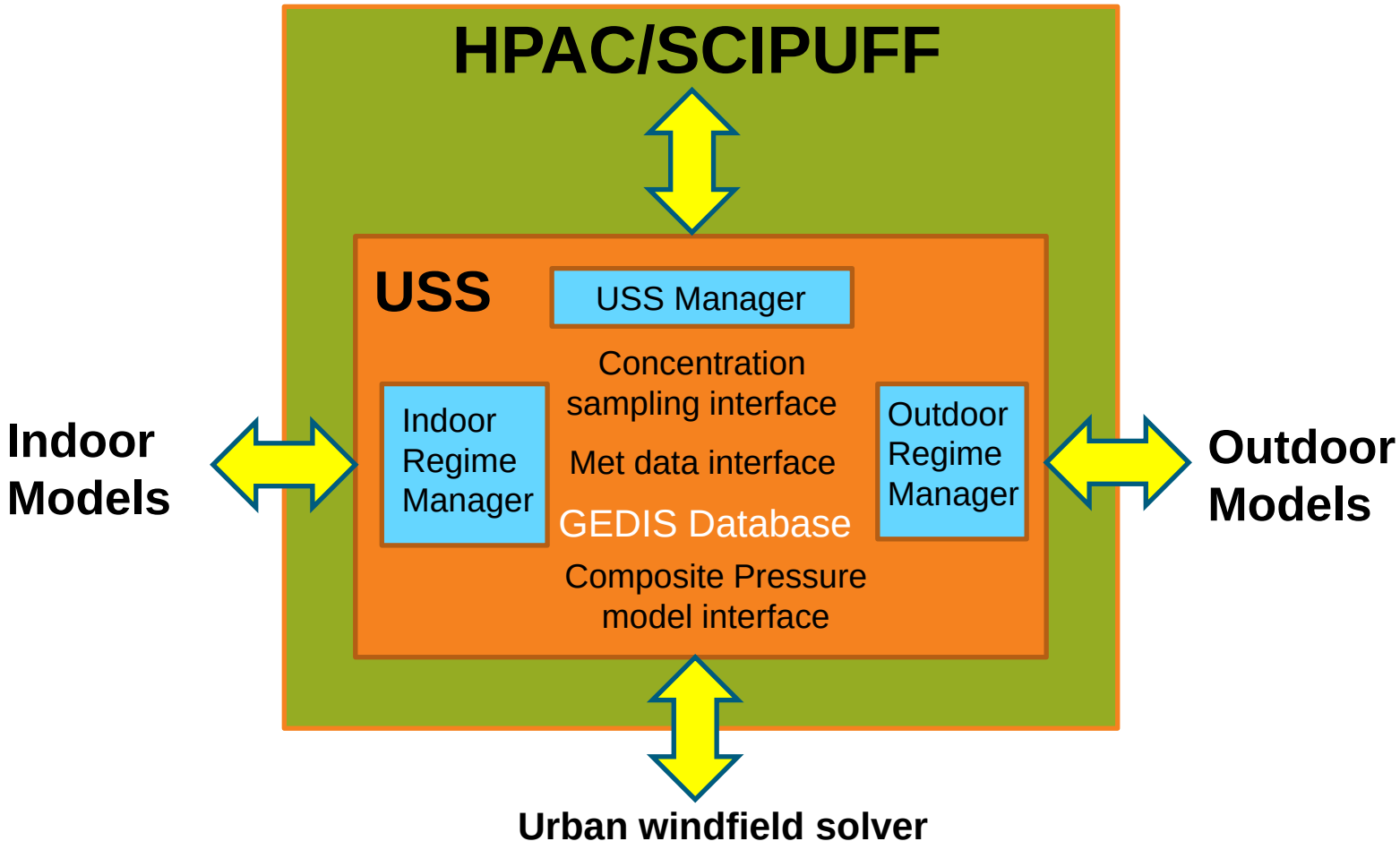
- The Defense Threat Reduction Agency (DTRA) Hazard Prediction and Assessment Capability (HPAC) enables the outdoor effects from urban releases of hazardous material to be predicted at 3 levels of fidelity.
- At present it has limited indoor-outdoor modelling capability.



The Urban-Sub-system (USS)

- USS is inserted in place of the Urban Dispersion Model (UDM) in HPAC.
- Prototype completed in 2011 enabled UDM to be coupled to:
  - Single zone: Building Infiltration Model (BIM);
  - Multizone: CONTAM and Confederation of Multizone Infiltration Specialists (COMIS) models.
- USS obtains indoor model data and access to indoor models through the Geographic and Environmental Database Information System (GEDIS).

The Urban Sub-system (USS)

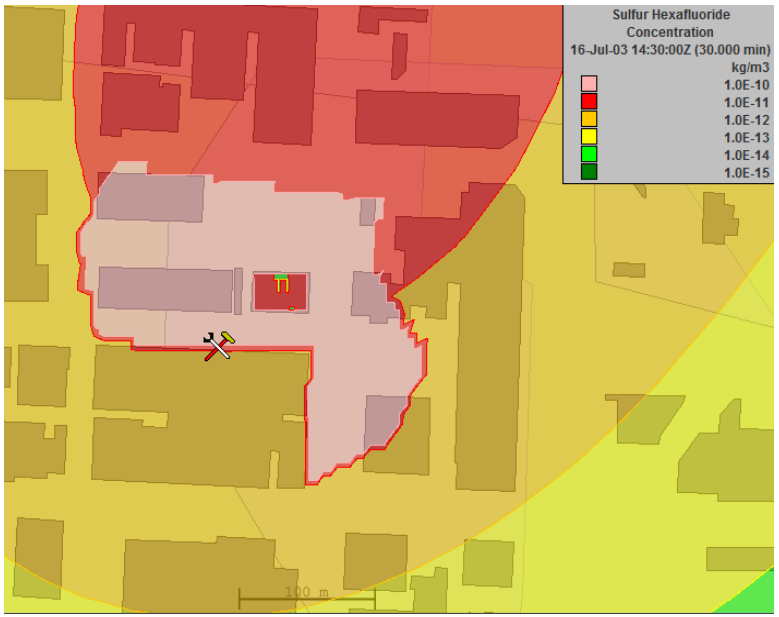


Current Work

- Enhancement of the USS and integration into HPAC to support decision making by first responders and scientists conducting pre- or post-event investigations following releases of hazardous material in urban environments through:
  - Enhancing USS modelling capabilities for Basic and Advanced users;
  - Examining indoor-outdoor model integration issues;
  - Developing user interface functionality;
  - Conducting code testing, verification and validation.

Improved Capabilities

- The prototype code has been refined to:
  - Enable CONTAM models to use urban windfield model data or simple meteorological inputs and pressure coefficients;
  - Enable temperatures in indoor models to be set;
  - Enable underground volumes to be taken into account.



UDM-CONTAM test case

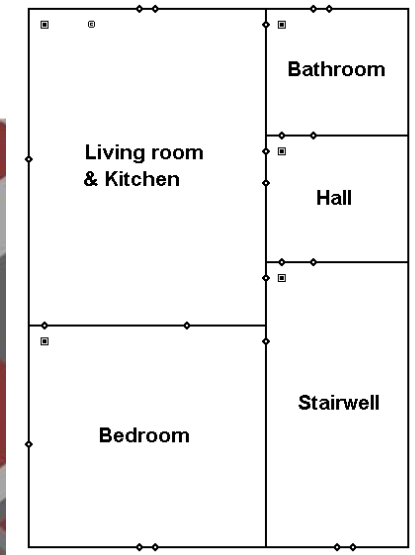
Indoor-Outdoor Model Integration Issues

- Questions:
  - Is it necessary to conserve mass when modelling infiltration, and if so under what circumstances?
  - What mechanisms should be used to implement mass transitions between outdoor and indoor models, or vice versa?
  - What are the information requirements for employing indoor models of different levels of fidelity?
- Examined using test cases based on two example buildings.

Residential Building

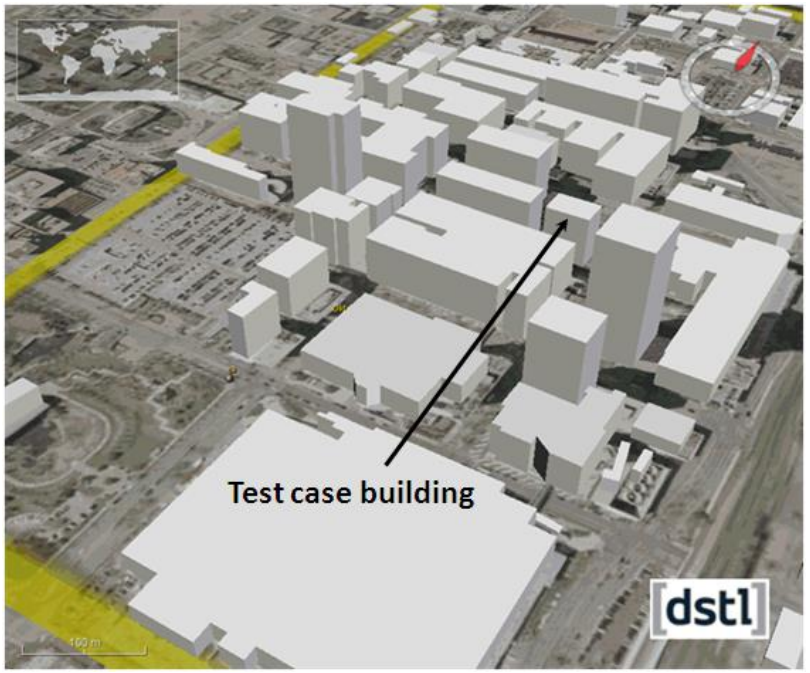
- Central London area used in the DAPPLE experiments;
- Four storey (12 m) end terrace townhouse;
- Four apartments;
- Four rooms and stairwell;
- Natural ventilation.
- Single zone BIM and 2 CONTAM multizone models.

Apartment floor plan



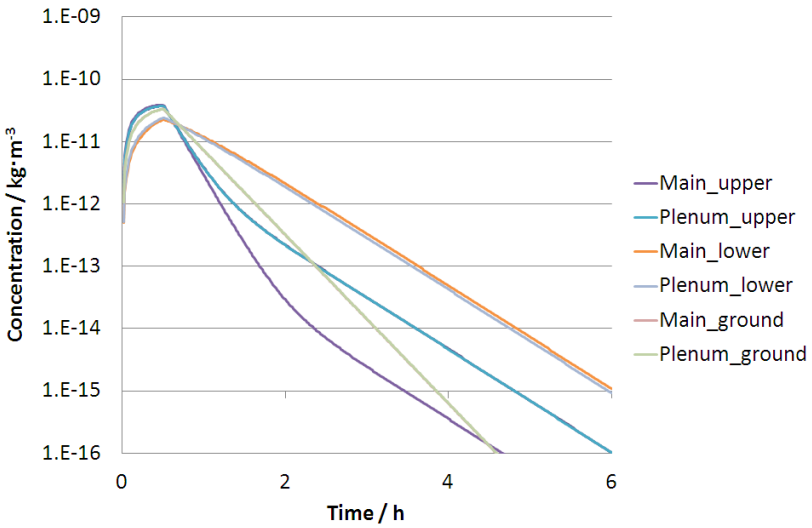
Large Office Block

- Office block in Central business district of Oklahoma city used in Joint Urban 2003 experiment;
- 14 storey plus basement and sub-basement;
- 3 ventilation systems, elevators and stairwells.
- Single zone BIM and 3 CONTAM multizone models (ventilation zone, floor and room level detail).

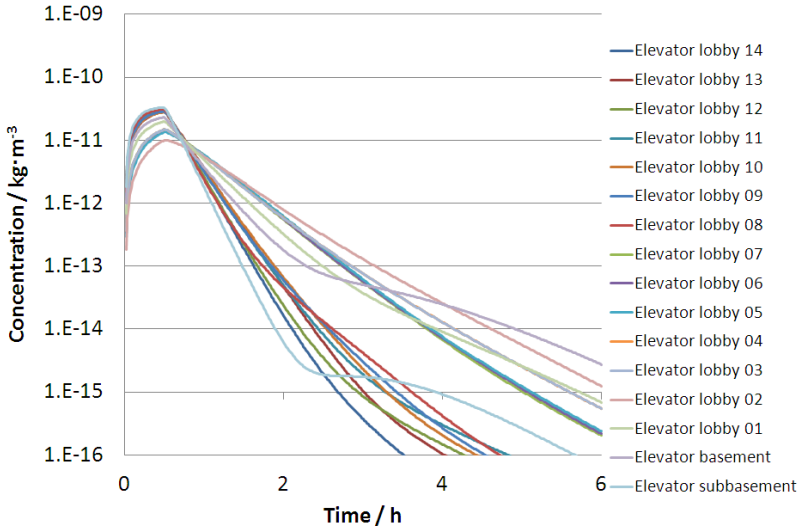


Effect of Model Fidelity

- Large Office block.



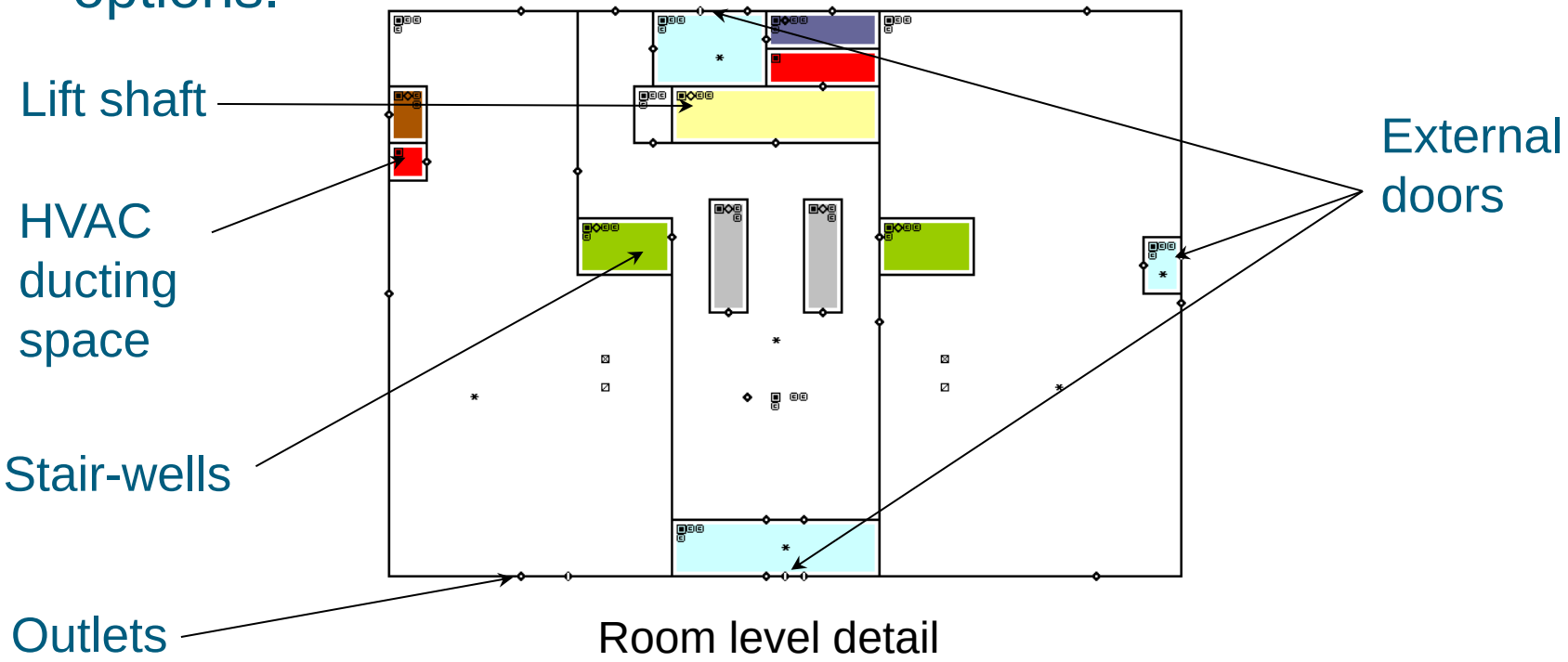
Ventilation Region



Room level detail

Detailed Analysis

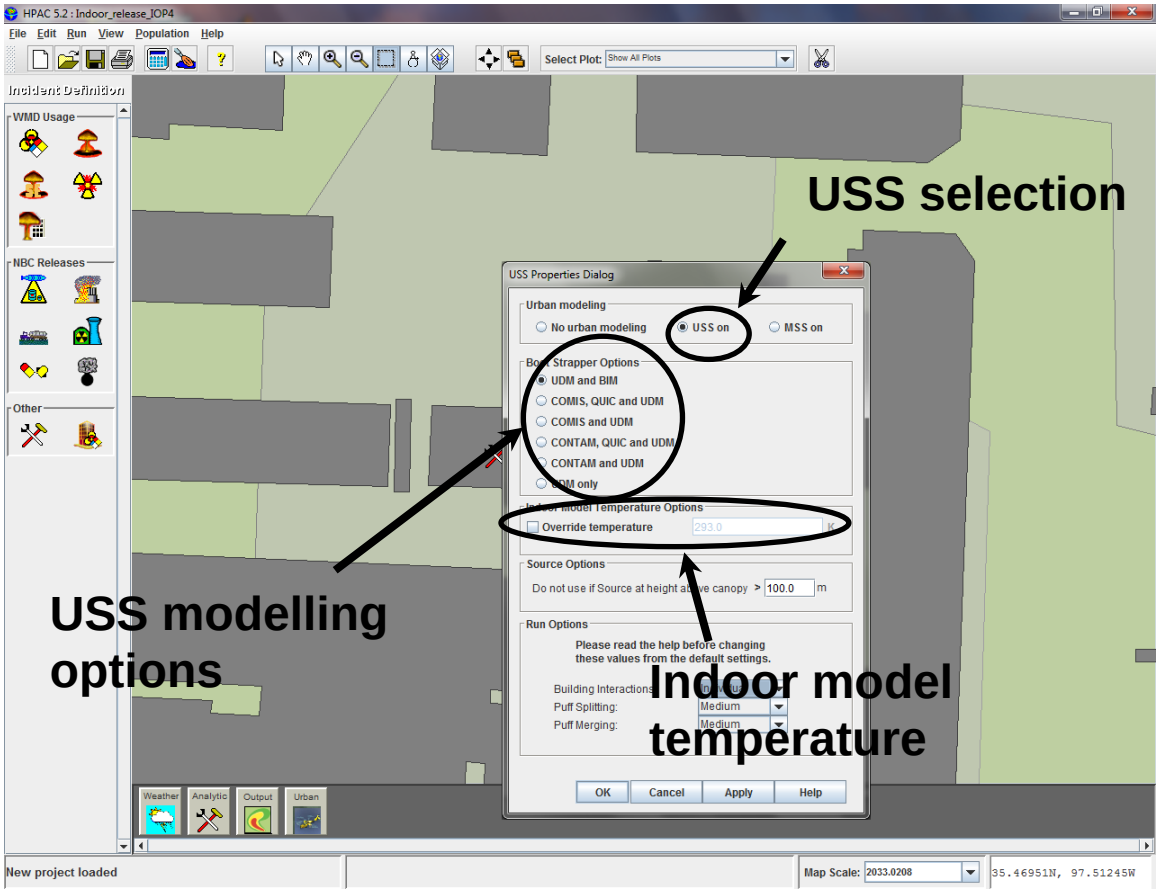
- Detailed analysis of results undertaken to understand importance of assumptions and to define USS user options.



Room level detail

Execution of USS Simulation

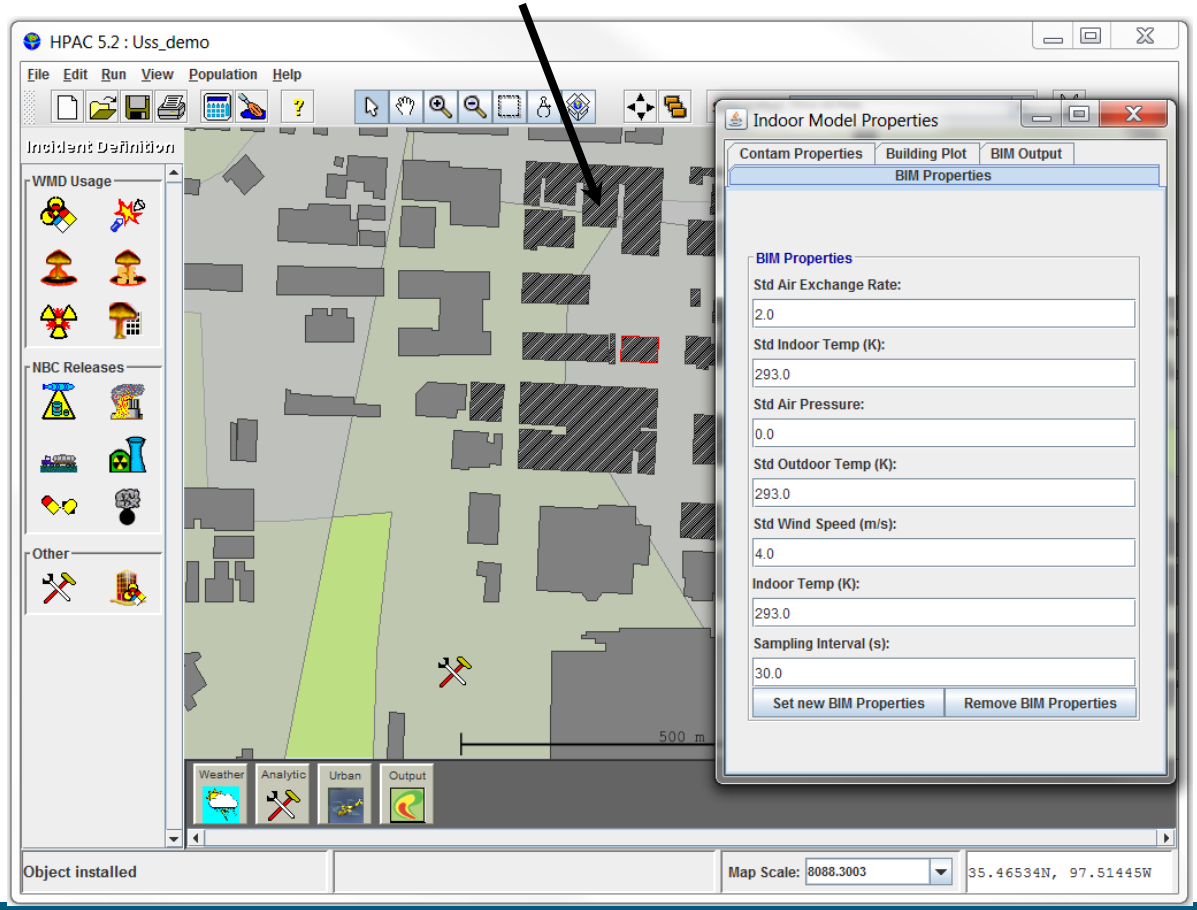
- USS is accessed through the HPAC Urban Button.



View Indoor Model Information

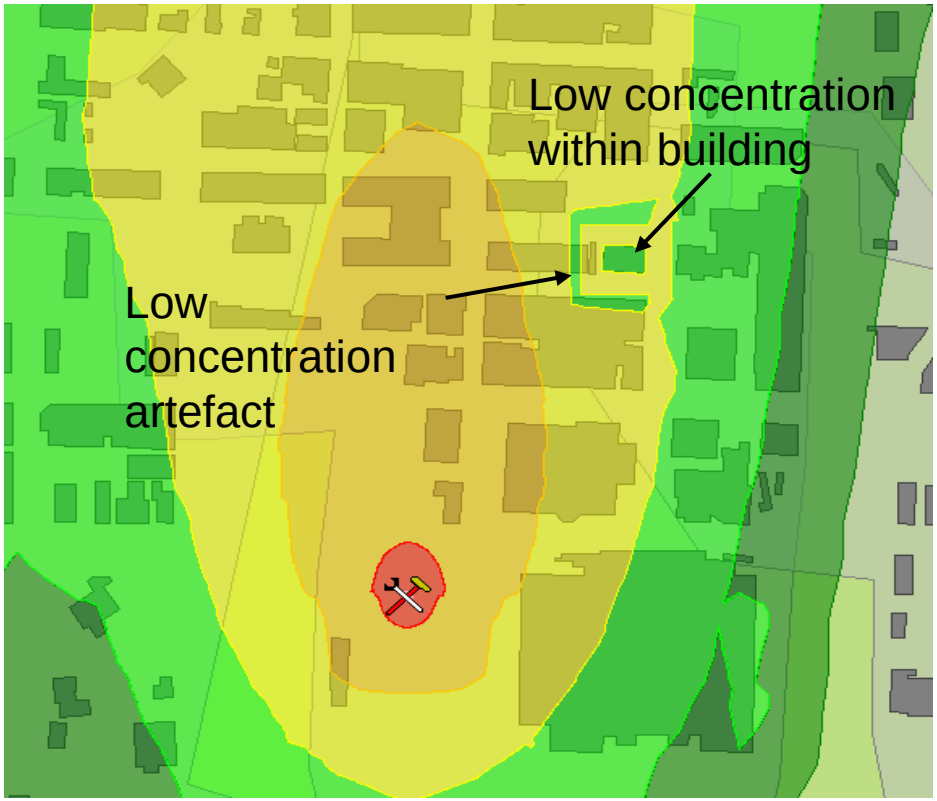
- Options prototyped using existing code in HPAC;
- Right ‘click’ to access indoor model properties.

Buildings with indoor models shown hatched

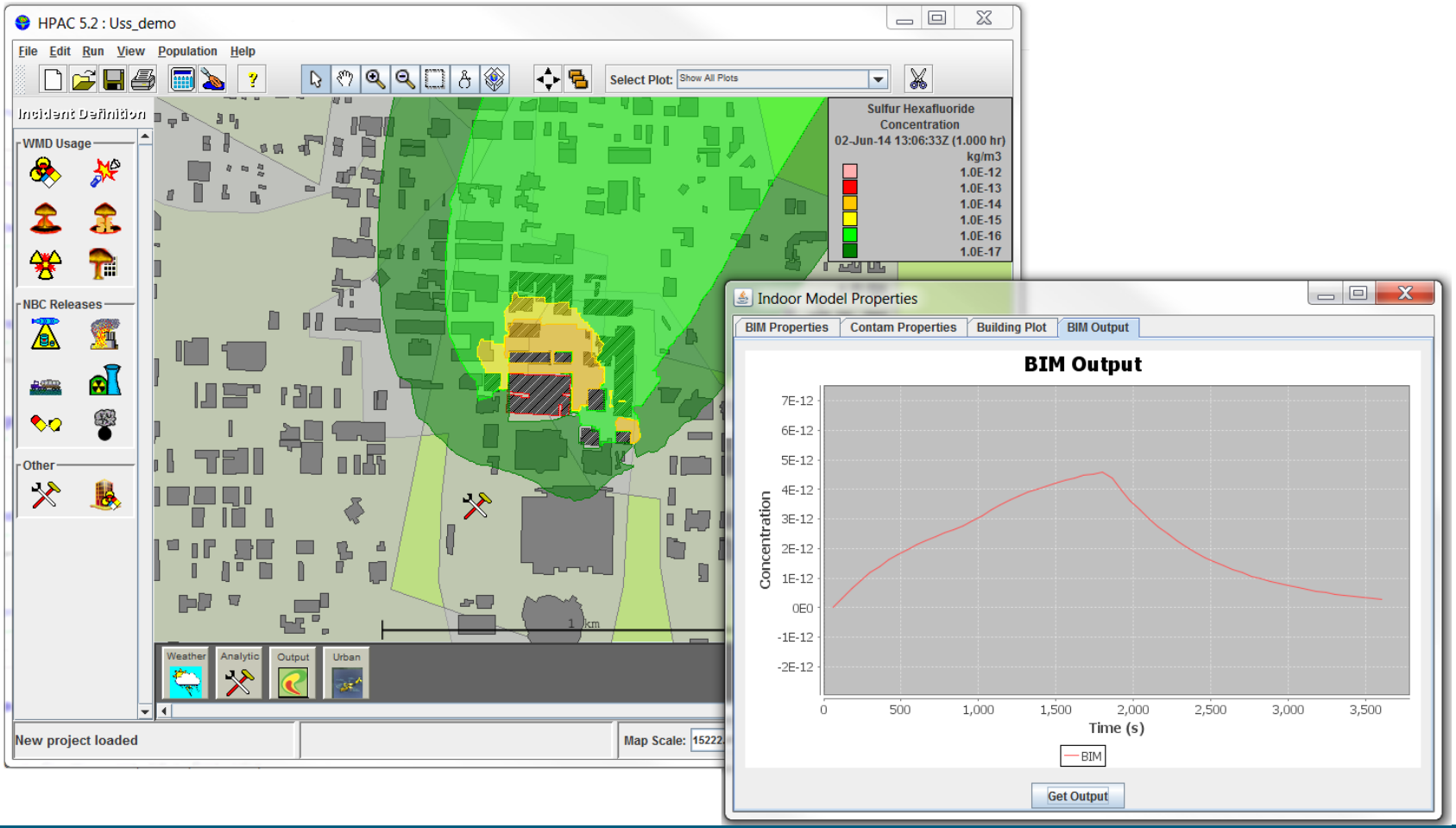


User Interface

- Modifications required to HPAC GUI to support use of USS:
  - Set up/verify indoor models;
  - Assess indoor model outputs.
- Separation of outdoor and indoor outputs appears best solution.

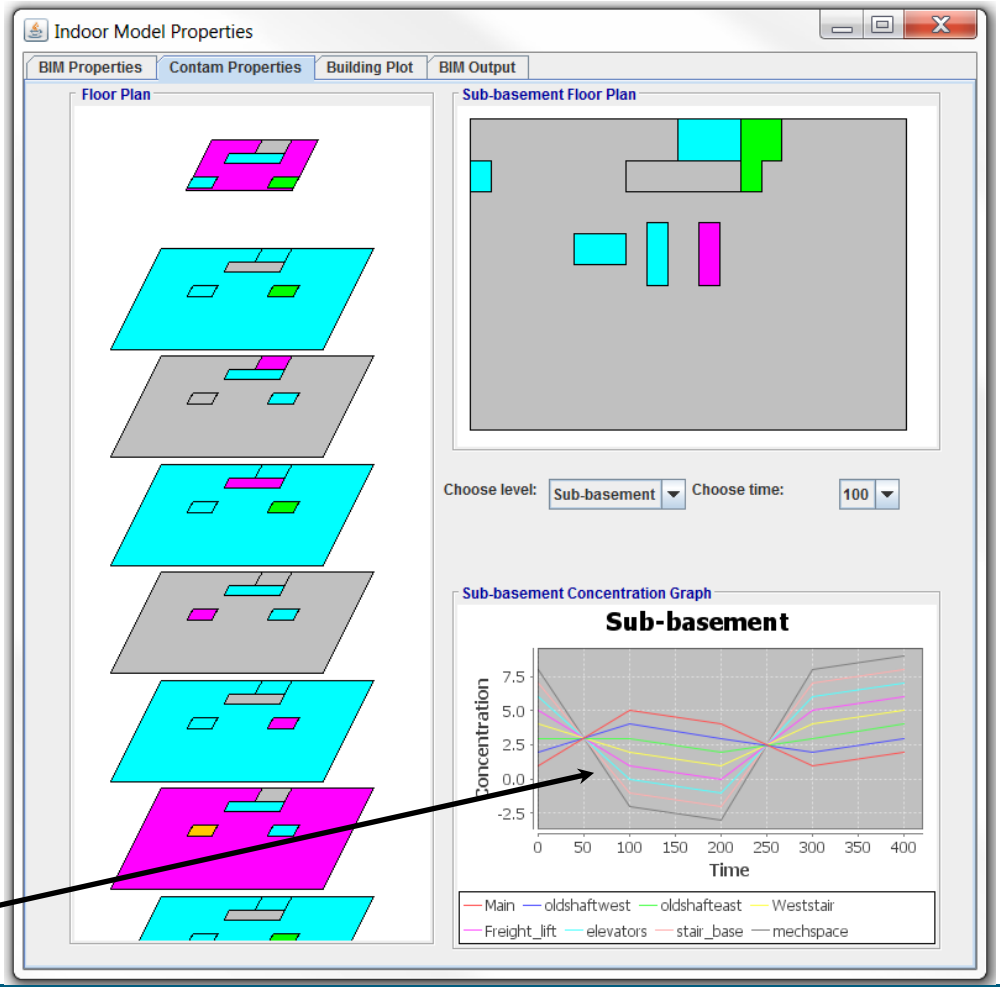


Prototype BIM Outputs



Prototype CONTAM Outputs

- Geo-referencing is minimised;
- Enables concentrations on floors and time histories to be plotted.



Concentrations in rooms

Testing, Verification and Validation

- Development of the USS imposes stringent requirements for testing to:
  - Verify that software provides the intended functionality;
  - Verify data is transferred correctly between models;
  - Assess that the USS can meet the required use cases;
  - Ensure that the user interface is satisfactory.
- To meet these needs, an incremental approach is adopted to software development and verification.

Further Developments

- Integration of MicroSWIFT/Spray as an outdoor modelling option;
- Implementation of prototyped output displays;
- Improvement of BIM to handle wider range of buildings including:
  - Buildings with ventilation systems;
  - Buildings with filters.
- Optimisation for rapid response using protection factors for wider urban areas and parameterisation of areas for single or multi-zone models.

Conclusions

- The USS is being developed to provide a coupled indoor-outdoor modelling capability in HPAC to Basic and Advanced users.
- Development and evaluation activities are:
  - Expanding and refining the implementation of coupled indoor-outdoor modelling options;
  - Developing interface modifications to enable USS to be used efficiently within HPAC;
  - Identifying the functionality to be provided to Basic and Advanced users.

Questions?