



Naval Surface Warfare Center, Dahlgren Division
CBR Modeling and Testing Branch



DoD Model Development for CWA Post- Decontamination Off-Gassing Hazard Estimation

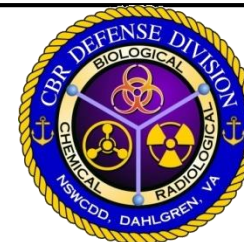
**2018 EPA International Decontamination Research and
Development Conference
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8-10 May 2018**

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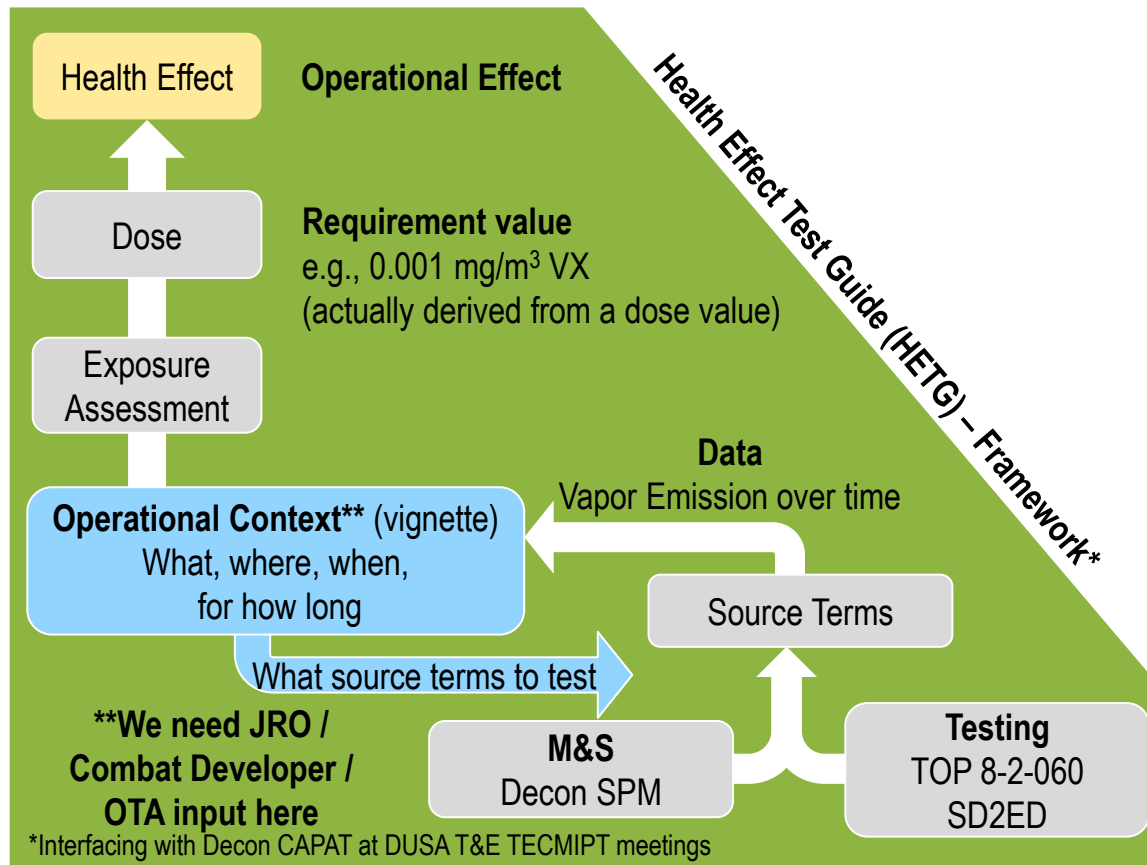
Introduction

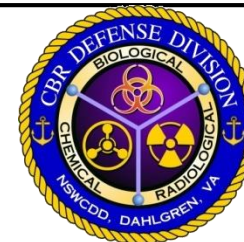
- **The Department of Defense (DoD) must be able to continue operations in the event of a chemical warfare agent (CWA) incident resulting in contamination of military equipment.**
- **Contaminated equipment must be decontaminated sufficiently that unprotected personnel will not experience toxic effects.**
- **Laboratory and chamber testing determine the post-decontamination vapor off-gassing fluxes versus time.**
- **Off-gassing data cannot be converted to human exposure.**
- **3 products cover the end-to-end evaluation process from threat to human response.**
 - ❖ **Heath Effects Test Guide (HETG)**
 - ❖ **Decontamination System Performance Model (Decon SPM)**
 - ❖ **Near-Field Downwind Hazard Model (NFDHM)**



HETG

- **Generate test data:**
CWA contamination + substrate + decon. process + environmental conditions
- **Models are developed from test data and theory**
- **Vignettes are defined from threat and operations**
- **Estimate post-decon. human exposure**
- **Convert exposure to health effects**
- **Determine if process meets requirement**



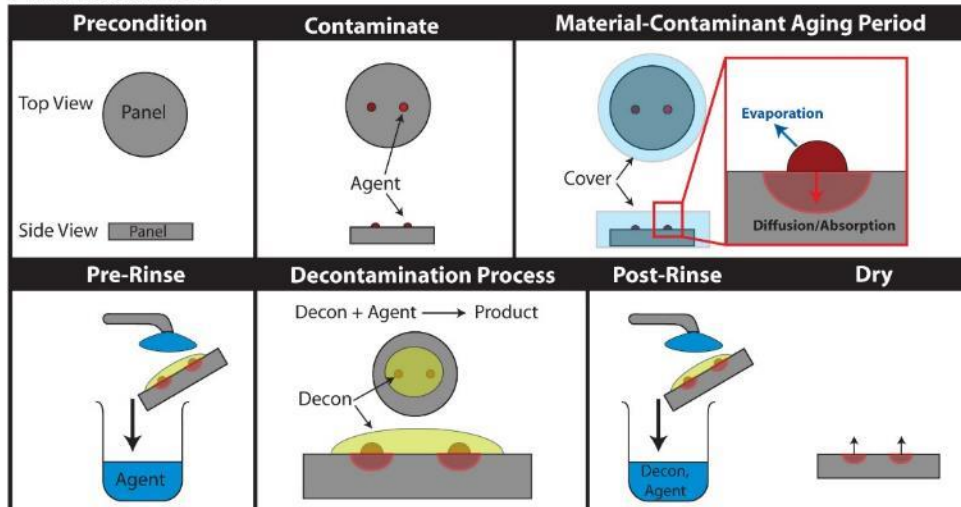


Test Data

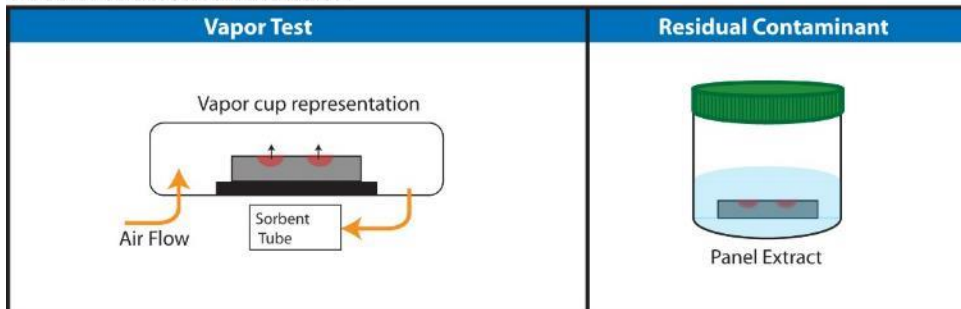
- Laboratory coupon test process and apparatus
- Provides off-gassing flux
- Can vary parameters in each step → need many tests



Panel Treatment



Post-Treatment Evaluation

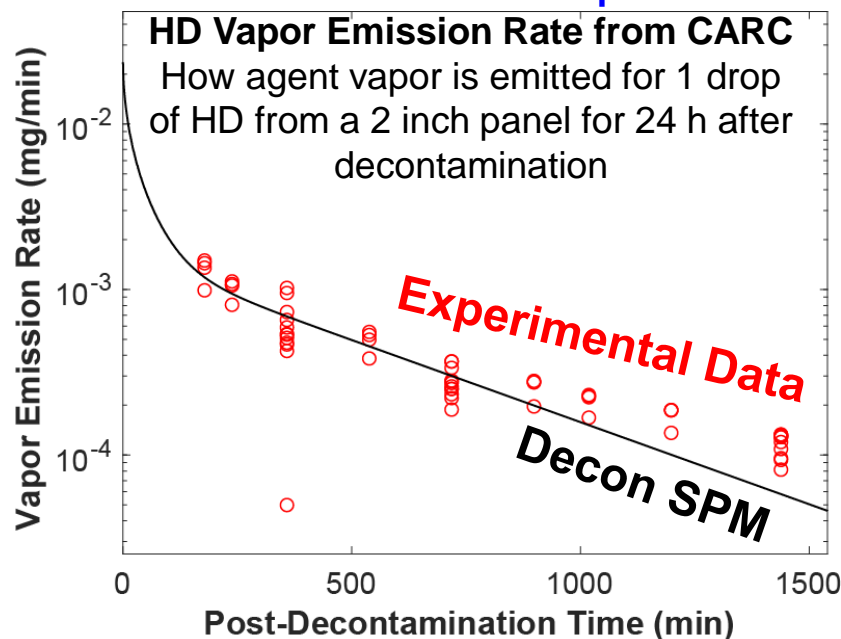


refs: ECBC-TR-980 and TOP 8-2-060

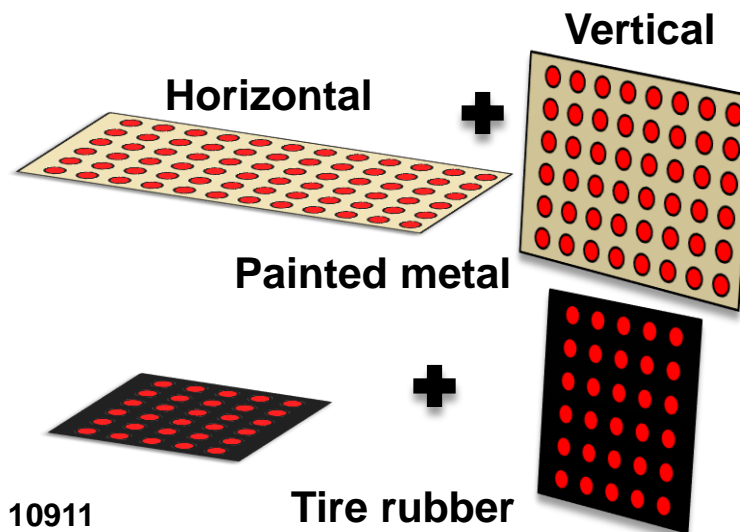
Decon SPM

- Model methodology allows each flux vs. time curve to be fit
- Theory can predict effect from temperature and wind speed
- Military equipment has multiple materials and orientations

Post-Decontamination Vapor Source



Material and Orientation: Wind tunnel panel testing



ref: Industrial & Engineering Chemistry Research, 2017, 56, 10911
<https://pubs.acs.org/doi/abs/10.1021/acs.iecr.7b02323>



Human Exposure



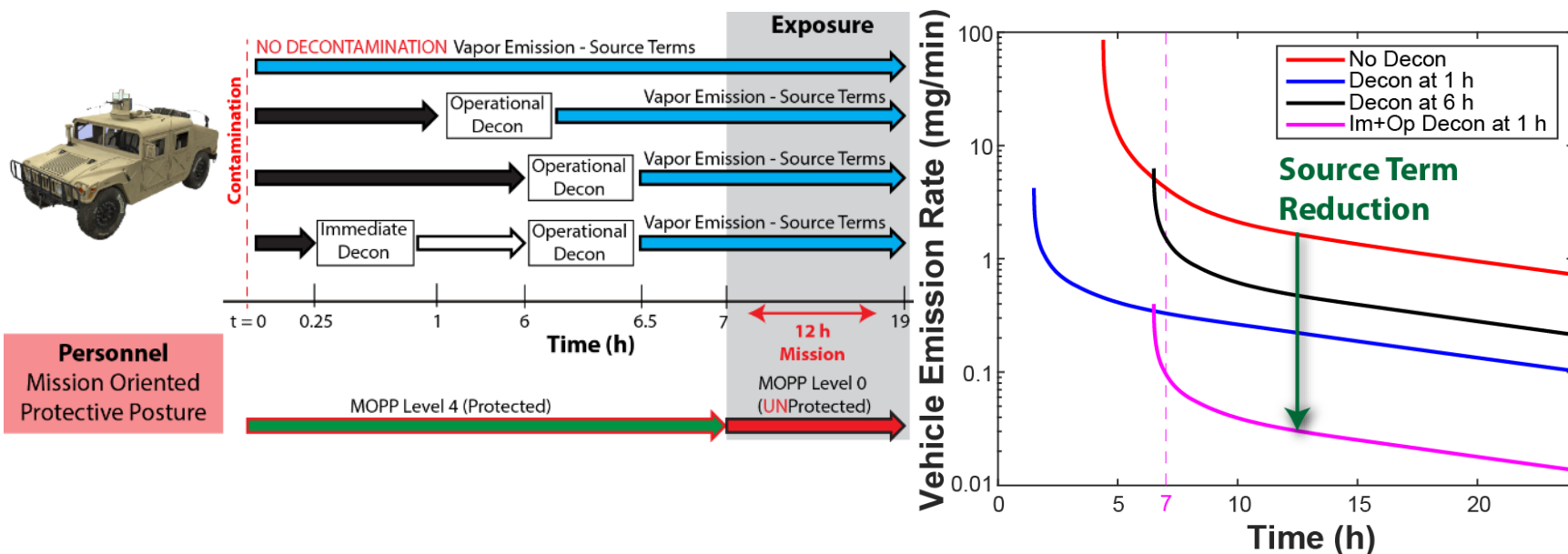
Indoor Exposure



Outdoor Exposure

- **Different model types for indoor versus outdoor exposure**
- **Vignette parameters: exposure time frame, how close and how long, stationary or moving, resting or active breathing rate**

Exposure Timing

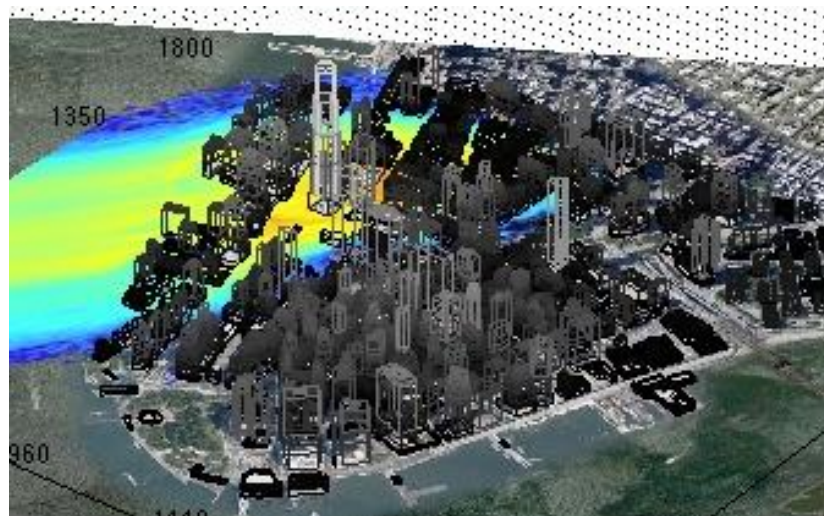
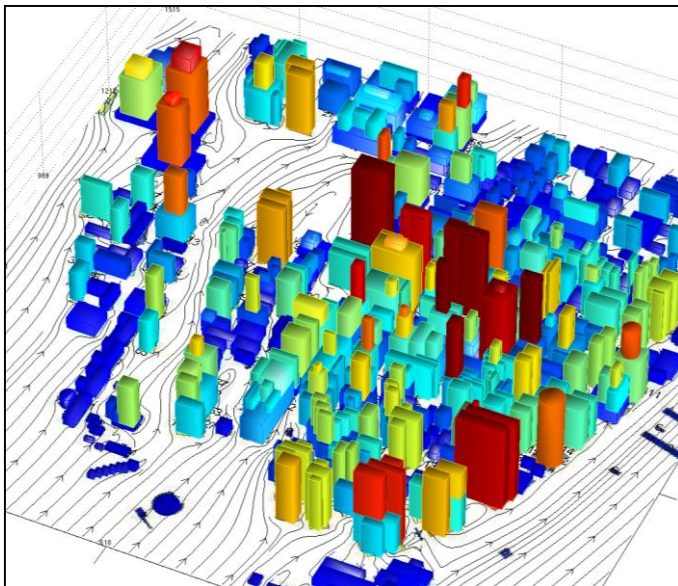


- The start time of exposure can be more important than the exposure duration.
- Off-gassing flux is highest immediately after decontamination.
- Absorbed CWA is more difficult to remove, so early decontamination is better.



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Near-Field Downwind Hazard Model (NFDHM)



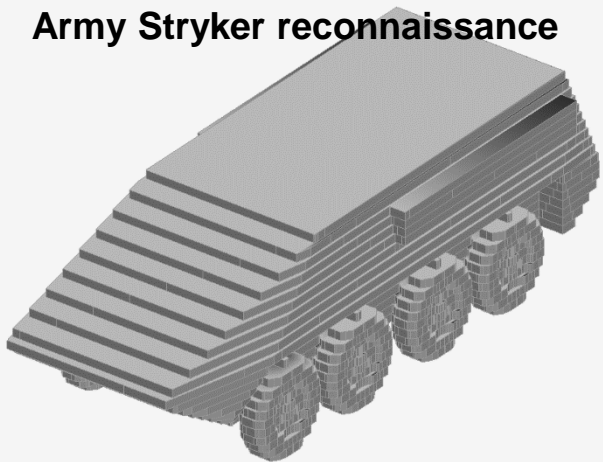
- **Based on the Quick Urban and Industrial Complex (QUIC) dispersion modeling system**
- **Fast-running code with graphical user interface**
- **3-D wind and pressure fields around buildings using empirical-diagnostic approach**
- **“Urbanized” random-walk plume dispersion modeling**
- **Advanced chemical, biological, and radiological source terms**



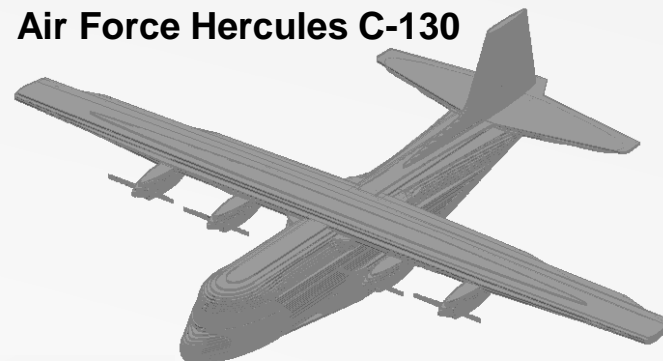
Military Equipment

QUIC was developed to simulate flow and dispersion around buildings → Scale translates to vehicles, aircraft, and ships, not personal equipment.

Army Stryker reconnaissance

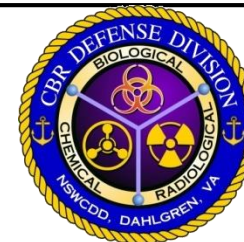


Air Force Hercules C-130



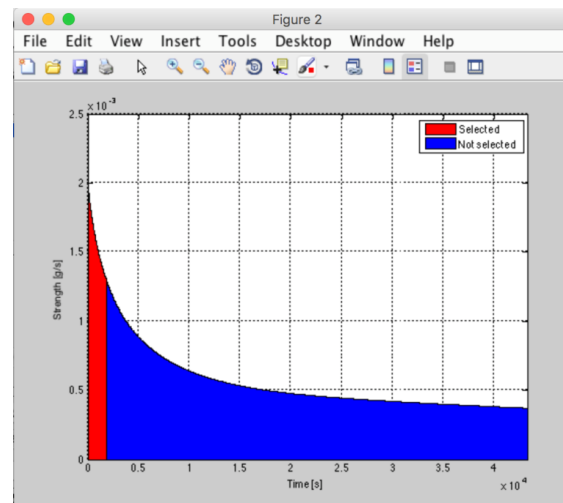
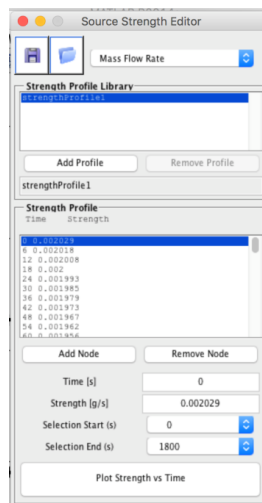
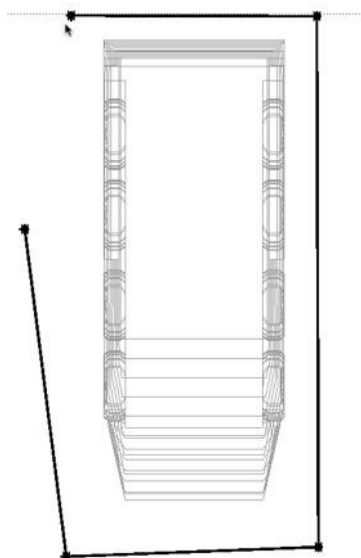
Navy DDG-51





NFDHM Operation

- Define each contaminated surface and select the off-gassing profile and exposure duration.
- Can select individual surfaces or entire object.

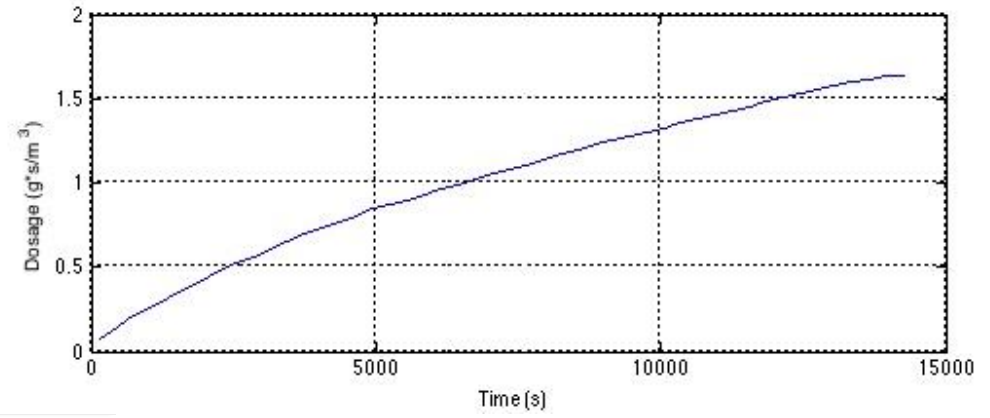
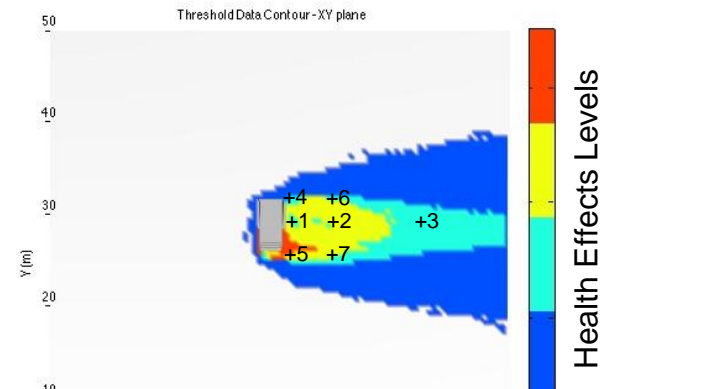


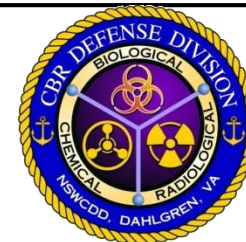


NFDHM Output

- Generate concentration, dosage, and/or deposition contours.
- Select specific locations for exposure versus time plot and file

The image shows two overlapping software windows. The top window is 'QUICPLUME Simulation Parameter Setup'. It has sections for 'Auto Update Plots', 'Simulation Start Time' (set to 8:00:00), 'Concentration Grid Parameters' (with X, Y, Z coordinates and upper/lower limits), 'Collecting Box' settings, and 'Simulation Parameters' (including Particle Release Rate of 6, Time Step of 0.2, Duration of 14404, Particle Output of 18000, and 'Conc Avg Time (s)' of 3601, which is highlighted with a red box). The bottom window is 'Observations Editor'. It shows a table of observation points with columns for Position1, Position2, Z(m), and Description. The 'Observation Averaging Period (s)' is set to 300 and is also highlighted with a red box. There are buttons for 'Add Observation Point' and 'Remove Observ'.





Current Status

- **HETG is still under development.**
 - ❖ Will include guidance on end-to-end decontamination system evaluation against human exposure requirements
 - ❖ Will reference key documents associated with the process, Decon SPM, NFDHM, and interior model
- **Decon SPM version 4.1 has been completed.**
 - ❖ Need test data for other CWA-substrate-decon combinations
 - ❖ Future version will also address CWA contact transfer
- **NFDHM is included as part of QUIC 6.29.**
 - ❖ Imports Decon SPM vapor flux files
 - ❖ Includes particle reaerosolization methodology, but test data are needed
- **Decon SPM and NFDHM also need complex object scale-up data for validation.**
 - ❖ Difficult to develop CWA-simulant correlations due to the complexity of interactions between the CWA and substrate.



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In Closing

Thank you for your attention.

Questions?