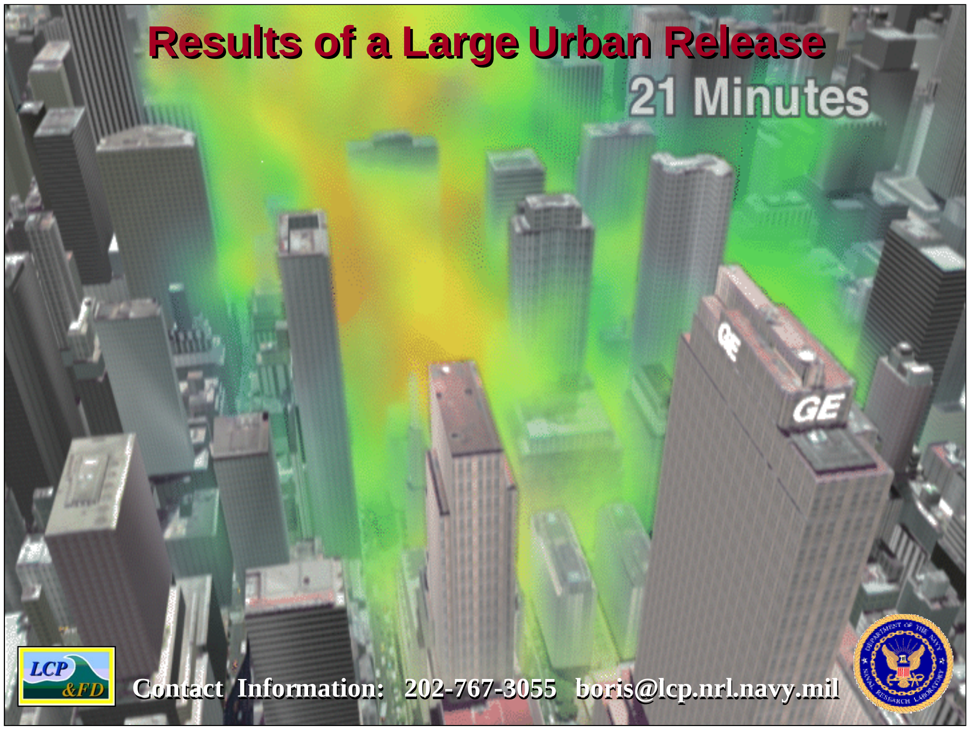
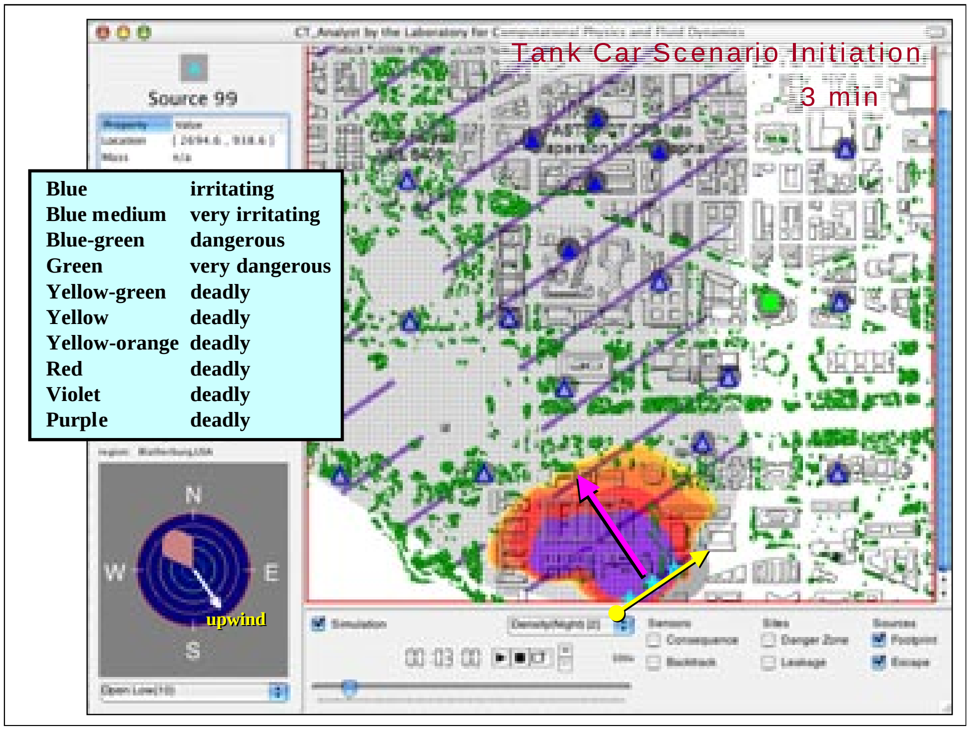

Results of a Large Urban Release
21 Minutes
GE
GE
LCP
&FD
Contact Information: 202-767-3055 boris@lcp.nrl.navy.mil

NOTES:

Advanced simulation technology gives us a practical breakthrough for analyzing and treating urban contaminant accidents, pollutant incidents, and in combating Chemical, Biological, and Radiological (CBR) terrorism. Today the nation is striving to develop plans and corresponding procedures to prepare for these contingencies. The ability to construct accurate, easy-to-understand analyses of dangerous contaminant release incidents is an absolutely crucial component of civil defense planning and execution. When decisions have to be made during an actual crisis, essentially infinite speed is required of the predictions and yet the analyses must be performed with high accuracy. When responding to a CBR crisis, waiting even one minute to perform simplified support computations can be far too long for timely situation assessment. State-of-the-art, engineering-quality three-dimensional predictions that one might be more inclined to believe can take hours or days. The answer to this dilemma is to do the most accurate computations possible well ahead of time and then to capture their salient results in a highly compressed database that can be recalled, manipulated, and displayed instantly during a crisis. Dispersion Nomograph™ technology was invented at NRL to provide this capability.

This presentation is based on a portable software tool called CT-Analyst™ that uses dispersion nomographs to combine information from sensors and eyewitness reports to find contaminant sources in an urban maze of buildings, to track airborne contaminant plumes accurately across the city, and to plan evacuation routes. In a crisis, real time users don't have to wait for any of these results because personnel defense plans and strategies can be adapted to current situation assessments with no delay for computing. This presentation uses CT-Analyst to show the evolution of a large contaminant plume caused by the rupture of a railroad tank car adjacent to the Blathersburg Mall.

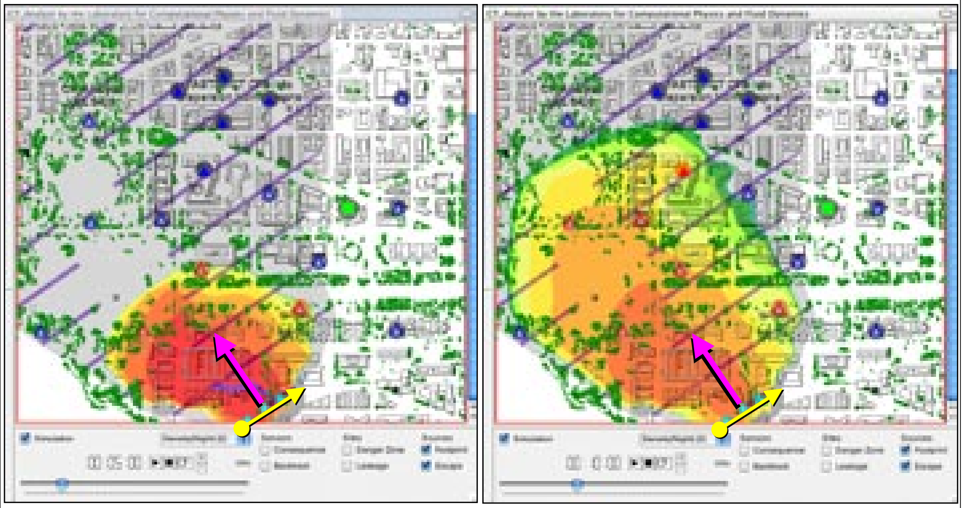


The figure above shows the contaminant concentration just three minutes after a railroad tank car accident has occurred along the indicated section of track where the right-of-way turns toward the east as shown by the yellow arrow. A large quantity of contaminant has been released in a couple of minutes. The time is late evening and the brisk breeze, from the southeast in this scenario, blows the cloud up toward a quarter of a million people celebrating Fourth of July on the Mall near the Blatherburg Monument.

The large gray area is the contamination footprint predicted by CT-Analyst™; this area can become highly contaminated in the first half an hour. It is a good idea get outside the footprint and stay outside of it until an "all clear" is given. The bands of color downwind of the the source, originating at the bright blue stars along the track, indicate the contaminant concentration in the cloud moving with the wind toward the upper left. The table tells how to interpret the colors in easily understood terms. The actual numbers, of course, can only be made specific and quantitative when the absolute size of the source is known. Each color marks approximately a factor of two range of concentration values. People breathing yellow green and "hotter" colors are in a very deadly situation. Not all colors appear on each figure because the contaminant concentration drops as the plume (cloud) spreads.

The diagonal purple lines in this and the following figures mark general suggested evacuation routes. The gaps in these lines show a kind of "no man's land" where the plume will go first and in highest concentration. People should walk briskly away from the center of the advancing plume along the general direction of these evacuation paths skirting around buildings and keeping to reasonable walking routes as required. Don't run and don't get in or stay in a car.

Blue	irritating	Green	very dangerous	Yellow-orange	deadly
Blue medium	very irritating	Yellow-green	deadly	Red	deadly
Blue-green	dangerous	Yellow	deadly	Violet	deadly



CT-Analyst Tank Car Scenario

Brisk breeze from the southeast

These two figures show the advancing plume at five minutes (left) and ten minutes (right) after the release occurred. Three adjacent blue stars are used to to mark the extended region over which this release has occurred from a moving railroad tank car. The yellow arrow indicates the direction of motion along the track and the pink arrow is the prevailing wind direction in each figure. The brisk breeze here is a worst case because slower winds allow much easier evacuation from the affected area and much faster winds dissipate the cloud so quickly that fewer people at any one spot receive critical dosages.

Almost everywhere in the plume after five minutes has elapsed (colored region) there is a high probability that the contamination will be lethal and almost all of the plume is still lethal at ten minutes. At ten minutes the lethal plume area is spreading at about its maximum rate. If 100,000 people receive critical (lethal) doses in the absence of any defensive action, they are crossing this critical dose threshold at the rate of a hundred people per second. Thus there is an enormous benefit to immediate warning delay and speedy defensive response.

Based on a number of other simulations not shown here and a consistent analytic theory, a warning issued within 3 minutes is possible with an automated sensor network and near complete situation assessment and response should be possible within five minutes. Though many procedural and communication problems remain to be solved, these times should be adopted as goals because so many lives will depend on making these response times as short as possible. Between five minutes and the current goal of issuing a warning in 15 minutes, 60,000 people or more could be critically dosed.

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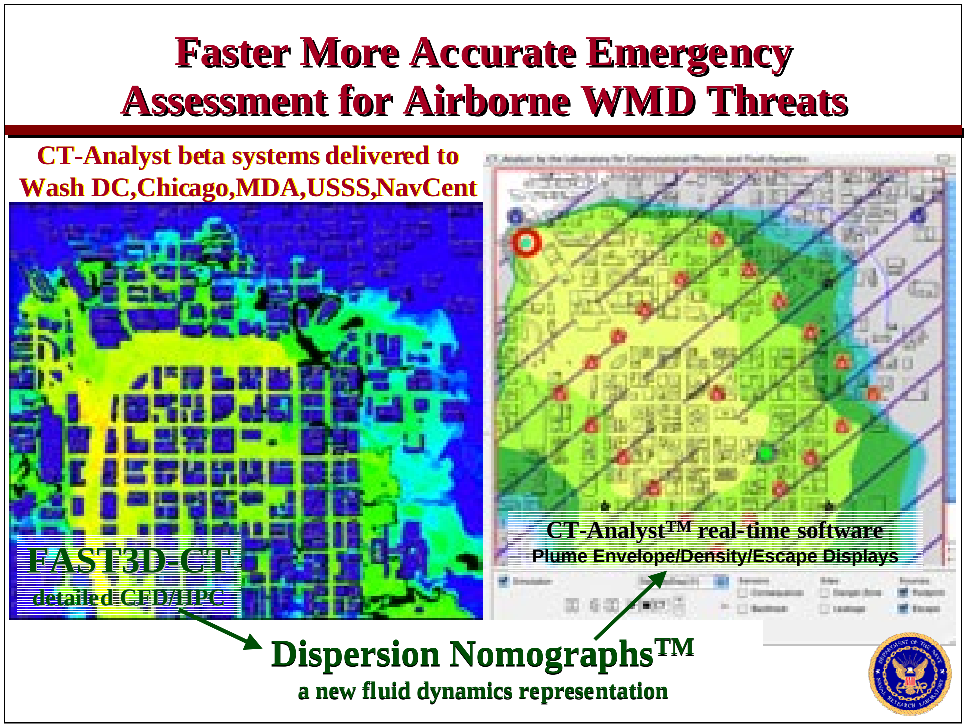
CT-Analyst Tank Car Scenario

Brisk breeze from the southeast

These two figures show the advancing plume in the previous scenario at 15 minutes (left) and 30 minutes (right) after the release has occurred. By 30 minutes the plume has spread laterally about as much as it will but it is still quite toxic and still expanding downwind off the edge of the nomograph. At 30 minutes the plume extends three to four miles downwind, is about 1.5 miles wide at its widest, and is still dangerously toxic as indicated by the large yellow-green region above right. If people are standing or sitting as much as 15 feet apart in all directions at an event on the Mall, there would be well over 100,000 people per square mile. Furthermore, the contaminant plume in this scenario will be dangerous over several square miles. Therefore, in the absence of an early warning and concerted action (rapid evacuation away from the centerline of the plume) over 100,000 people could be seriously harmed or even killed in the first half an hour.

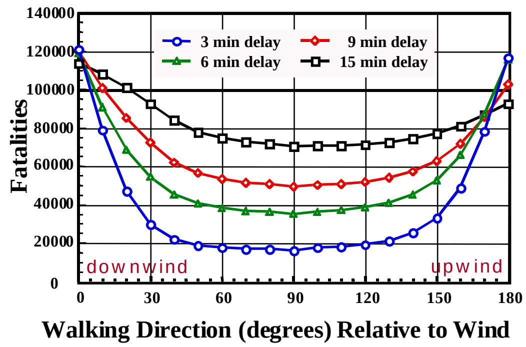
Although this is a dire scenario, the people several miles downwind from the source, in this example a couple miles off the upper left corner of the figures, have plenty of time to walk out of the way of the plume given a warning in five minutes or less. They would have to walk only about 3/4 of a mile at most to get completely out of the plume and would have 20 to 25 minutes to do this. Walking is recommended in urban areas since the roadways should be kept open for emergency traffic and will gridlock instantly if everyone tries to leave in their cars at the same time.



Detailed, three-dimensional FAST3D-CT simulations (such as shown at left) are compressed by more than a factor of 10,000 to produce compact data structures called Dispersion Nomographs**™**. These "nomographs" allow CT-Analyst**™** to make accurate, instantaneous predictions including the effects of buildings (as shown at right). This example shows the situation 18 minutes after a contaminant release occurred at the location marked by the blue star with the wind from 320 degrees at 3 m/s. This CT-Analyst display shows the instantaneous plume concentration (colored bands) superimposed on the footprint of the likely contamination region (light gray). The footprint can eventually become contaminated beyond tolerable limits sometime during the scenario. The plume region displayed surrounds the instantaneous plume - with a safety buffer zone. CT-Analyst is in use at a number of locations (see figure), was transferred to NAVCENT during Operation Iraqi Freedom, and is being modified as a CBR Emergency Assessment System for installation in Navy bases over seas.

CT-Analyst performs multi-sensor fusion operations based on the very limited information about the contaminant density based on anecdotal reports and yes-no sensor readings. Also overlaid on the CT-Analyst display are a number of sensors active and operating in automatic mode (triangles) and manual mode (circles) to register the presence or absence of the agent plume at their location. Red indicates a "hot" sensor (something considered dangerous) and blue indicates a "cold" reading where the contaminant agent density is below the threshold for detection. Please note that the "Escape" function has also been activated in this composite display, projecting optimal evacuation routes over the contaminant concentration contours. These recommended evacuation routes suggest walking directions for rapid egress from the path of the advancing plume. They continue out to the edges of the contamination footprint. This entire assessment takes about 50 milliseconds on a typical windows laptop computer.

Emergency Selection of Effective CBR Civil Defense Options



Some "Rules of Thumb"

- **"Detect to Protect" requires timely warning and defensive action**
- **Evacuation is generally more effective than "sheltering in place"**
- **Sheltering is preferable only when building filtration is in place**
- **Each building should be considered separately based on its ventilation system and location to minimize people's exposure**

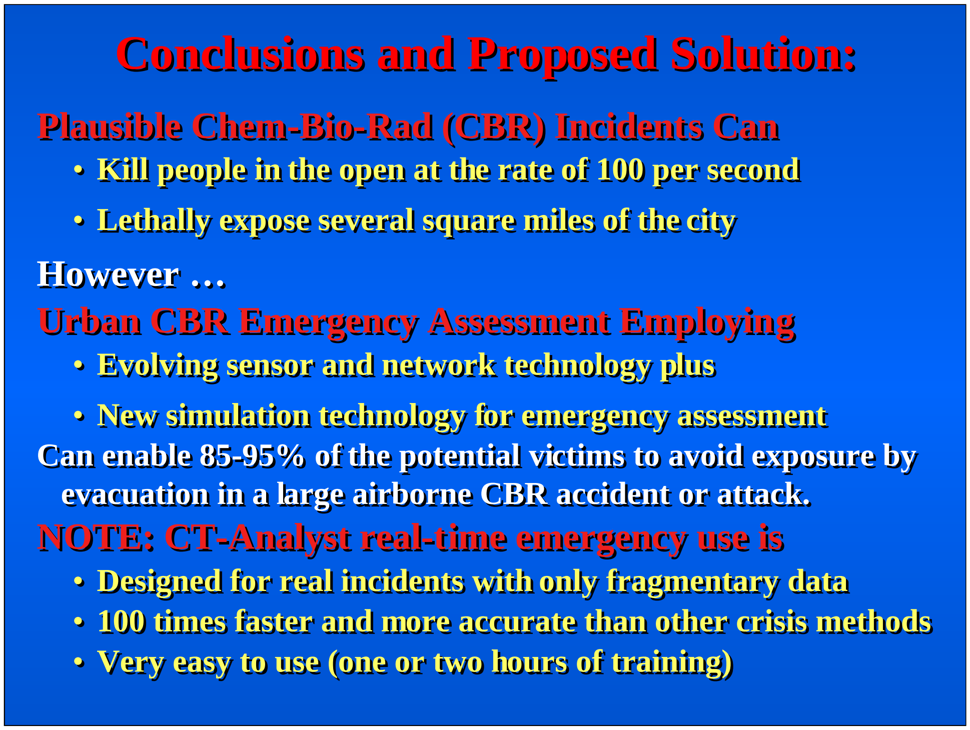
Immediately Required for Effective Chem-Bio Defense

- **Ability to determine unknown locations of contamination sources**
- **Ability to predict plumes & contamination footprints instantly**
- **Ability to combine and analyze information from many inputs**
- **Ability to choose between evacuation and in-building defense**

The message is clear, walking perpendicular to the wind away from the centerline of the plume is the only effective direction to walk, as indicated automatically by CT-Analyst. There is a wide range of angles, plus or minus 30 degrees, for which this strategy is effective but the effectiveness declines the longer the delay in receiving a warning. For large contaminant sources, simple theory and detailed computer simulations both suggest that 85 to 95% of the people who would otherwise be exposed can avoid exposure, regardless of what the agent is, when the appropriate warning is issued without delay.

What also becomes apparent is that solid information, as well as prompt warning and action, reduces exposure. Knowing the location of the contaminant source, the wind speed, and its direction can save tens of thousands of lives. Combining an integrated city sensor net with accurate models incorporating the unique building/terrain features is the key to defining the centerline of the plume based on source location and thus determining effective escape routes. A CBR Emergency Assessment System must be instantaneous and capable of incorporating changing wind and sensor data as they become available. Only centralized analysis and prompt communication can define the safe routes away from an invisible cloud.

These CBR emergency assessment tools have been used to evaluate and compare a number of possible CBR defense strategies. The model on which this graph is based follows hundreds of thousands of people who begin walking (evacuating) in a specified direction relative to the wind once a warning is issued. The computed contaminant density is integrated to determine each persons dose. This "warning delay" is varied to measure the reduced effectiveness of evacuation as the warning delay gets too long. Zero (0) degrees is walking downwind, 90 degrees is across the wind (perpendicular) to the plume centerline, and 180 degrees is walking upwind.



We have shown that plausible accidents or terrorist attacks in an urban environment can put 100,000 people or more at risk in a 15 to 30-minute time span. During this interval several square miles of city can become lethally exposed and people can die at the rate of 100 per second. Clearly there is a very great premium or fast effective response.

The point is - we already have accurate, fast tools based on tested scientific models for computing the detailed airflow and converting these data sets directly to critical civil defense information. An urban CBR Emergency Assessment System (CBREAS) based on this new technology can instantly combine information from eyewitness reports and CBR sensors to locate hidden sources, can estimate regions about to become contaminated, and can predict effective evacuation paths. This new technology faithfully incorporates the 3D structure of urban building mazes and has reasonable sun, wind, and information-display options. The challenge is to harness these tools effectively in the current political climate. If police, fire department personnel, and emergency first responders use this technology to obtain a minute-by-minute situation assessment and implement an action plan, they can reduce exposures, even of large crowds in the open, by 85 to 95% provided that an early warning is issued.

Sales Pitch: The CT-Analyst contaminant transport system is ACCURATE. Plume envelopes are 80-90% as accurate as state-of-the-art 3D computational fluid dynamics. CT-Analyst is VERY FAST with performance 1000 to 10000 times faster than real time. This can make the difference in saving tens of thousands of lives in a real attack. It is also very EASY TO USE. Two hours of training should be adequate. CT-Analyst also be used for war games, virtual reality training, site defense planning and execution, and sensor network optimization. The CT-Analyst software has stabilized and is very rugged.. The software also allows the user to displace plumes by dragging the source across the screen, and can “backtrack” to find hidden sources. CT-Analyst will also project optimal evacuation routes.