

GIS for Threat Analysis

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GeoIntelligence

When disaster strikes, the ability of the public and private sectors to react effectively depends substantially on how well they have planned their response strategies. But to plan such responses requires an understanding of a variety of attack scenarios. That's where spatial technologies for threat assessment come into play.

In the past two years, state and federal legislators, their staffs, the media, first-responders, and numerous other organizations have learned a great deal about terrorist threats. This education has been bolstered by such tools as satellite imagery and geographic information systems (GIS), which can be used to forecast and model potential hazardous events and the emergency response to those disasters.

For instance, using desktop or Web-based GIS, analysts can model the dispersion of a nuclear, biological, or chemical plume. These specialists can overlay these models onto a city map to examine how attacks would affect given areas and populations. Threat-assessment advisers then can run various scenarios to plan optimal evacuation routes and determine where to place decontamination facilities and chemical/biological detectors.



"Modeling Security for the Winter Olympics" sidebar. Click to enlarge.

Among the well-tested programs for visualizing these scenarios both at home and abroad are Consequence Assessment Tool Sets (CATS) and Hazard Prediction and Assessment Capability (HPAC). Used primarily for domestic threat assessment because of its in-depth U.S. city-level data, CATS is a set of models that simulates both natural and manmade catastrophes -- from earthquakes to chemical weapons attacks to hazardous material spills.

With a few extensions, CATS enables users to generate predictive models and conduct casualty and damage assessment. HPAC, similar to CATS but with more international data and a larger variety of non-conventional threat scenarios, is more often used to model threats abroad. The two GIS computer models have proven invaluable for policy briefings, public education, and event preparation (see "Modeling Security for the Winter Olympics" sidebar) during the past few years.

Modeling with Weather and Facilities Developed by Science Applications International Corporation (SAIC) just after the first Gulf War, CATS and HPAC have helped civilian first-responders, military intelligence units, and National Guard civil support teams better grasp the consequences of nonconventional threats. The Defense Threat Reduction Agency (DTRA) monitors distribution of both. The technologies allow the modeling of scenarios based on current weapons technology and past results from biological, chemical, and radiological experiments.

The models are based on data pulled from the DTRA database and combined with more than 150 other databases, including census, nuclear plants, military bases, ports, and superfund sites. In addition, the new Joint Assessment of Catastrophic Events program allows for an actual satellite image to overlay a traditional GIS street map theme. Commercial, space remote sensing companies now can provide in-depth

satellite imagery of buildings, which opens a new world of analysis. Soon, such firms will be able to develop scenarios that assess structural damage to buildings and casualty estimates for those within.

The analysis becomes even more accurate when it links directly to the National Weather Service (NWS) and pulls regional weather for the time the simulated event takes place. This can involve either forecasted weather or, if the event is too far away for an accurate forecast, historical averages of weather over the past 20 years. The program then produces a map that shows the areas affected, populations, and the level of lethality of the attack.

To demonstrate the value of CATS, we begin with some examples from Los Angeles, California; Washington, D.C.; and Houston, Texas.



Figure 1 (Click to enlarge). Anthrax sprayed over Los Angeles County, with easterly winds as modeled here, could affect as many as three million people given this CATS scenario and assuming no protective gear.



Figure 2 (Click to enlarge). An airborne release of 45 kilograms of 99 percent pure botulinum toxin over Washington, D.C. could impact nearly 200,000 people, as demonstrated in this model.

bomb small enough to be hidden in a briefcase. It levels downtown Houston, flattening most of the 58 skyscrapers and killing about 130,000 workers (see Figure 3).

Domestic Terrorism

Scenarios At the request of U.S.

House and Senate staff -- as well as media outlets such as The Houston Chronicle, Washington Times, York Daily Record, and The Times (London) -- we used CATS to model a variety of scenarios involving several American cities. Specifically, we simulated dirty bombs detonating in downtown areas; a crop duster spreading anthrax, sarin, botulinum toxin, or nerve gas over large populations; a nuclear reactor leak; a missile intercept; and a nuclear explosion (see Figures 1 and 2). In Houston, the media used our model to challenge local government officials regarding their disaster-preparedness plans.

Following the first anniversary of Sept. 11, Mike Hedges of The Houston Chronicle interviewed local authorities and first-responders to see if his city was prepared for the terrorist attacks we modeled. He also asked local, state, and federal officials to describe how they would respond to these scenarios. In a graphic front-page story, he described a nuclear bomb small enough to be hidden in a briefcase. It levels downtown Houston, flattening most of the 58 skyscrapers and killing about 130,000 workers (see Figure 3).

This simulation included data from ESRI Streetmap, the NWS, and the National Imagery and Mapping Agency (NIMA). Streetmap contained the necessary detailed road information and map layers of downtown Houston. The CATS software ties to NWS's database to get the latest forecast information to determine the plume dispersion. Additional map layers (buildings, parks, water bodies, and so forth) came from NIMA sources. All the data were plotted in a geodetic coordinate system (degrees latitude and longitude).

Our simulation had the bomb explode outside City Hall, destroying it, the Houston Police Department's headquarters, and the Harris County administrative offices. It killed most local leaders and law enforcement officials, crippling the city's ability to respond to the disaster. Based on the simulated weather data, the wind dragged the radioactive cloud through the East End and beyond the I-610 Loop, killing 10 percent of those in its stream and leaving thousands more ill.

Houston authorities had considered disaster scenarios in planning emergency responses, but the simulation and Hedges' article fostered debate about how prepared the city was for an attack. The discussion pointed out deficiencies for the city to address. Following Houston's lead, many other localities performed similar simulations to test their preparedness.



Figure 3 (Click to enlarge). In this scenario, a nuclear "suitcase bomb" explodes in downtown Houston, demolishing a nine-block radius (shown in red). Seventeen mile-per-hour winds blow the radioactive cloud (the plume spreading to the right) east, with lethality diminishing (orange, yellow, green, and so on) as the plume travels.

From Over The Border. A recent Heritage Foundation Homeland Security Task Force, for instance, used CATS to help assess port and border security threats. The analysis shows the U.S. is still vulnerable even if the attack doesn't start on U.S. soil. The group ran four nuclear and biological scenarios, looking at the border cities of Detroit, Michigan; San Diego, California; Buffalo, New York; and El Paso, Texas.

One mock scenario modeled a nuclear explosion in Mexico across the



border from El Paso. After purchasing an old Soviet suitcase nuclear weapon in Central Asia, a terrorist smuggles it into Mexico to detonate it near the U.S. border. Traveling by car, the suicide bomber makes his way toward El Paso. South of the border, he pulls into a vehicle inspection station and detonates a 3-kiloton nuclear bomb, equivalent to 3,000 tons of dynamite. In this scenario, much of El Paso is devastated, even though the bomb exploded on the other side of the border. Prevailing winds blow radiation to San Antonio (see Figure 4). Authorities do not know if this is a single attack or a precursor to other attacks. Fortunately it's just a simulation. But it does help to better prepare the local and federal authorities and first-responders that would be involved in such a catastrophic attack.

Figure 4 (Click to enlarge). In this assessment of border threats, CATS analysis showed that some U.S. cities are vulnerable to attacks in neighboring countries. In this instance, fallout from an attack in Mexico is carried by prevailing winds to impact El Paso and San Antonio, Texas.

Clearly, prompting such discussions has great value in shoring up emergency planning here in the United States. As useful as the previously discussed models are, GIS software that enables battle management modeling is even more advanced.

Battle Management In addition to CATS and HPAC, the U.S. Air Force, for instance, uses its own command and control mapping software for its Theatre Battle Management Core Systems Unit Level (TBMCS-UL). This GIS software, deployed at Air Combat Command and Pacific Air Force Command bases around the world, monitors conventional attacks as well as nuclear, biological, or chemical attacks on a particular installation. Base commanders and decision makers then can determine how to best use their war-fighting assets and more importantly, protect military and civilian personnel via bunkers and protective clothing.

Exercise scenarios, similar to those done with CATS and HPAC, are done with great regularity in Operational Readiness Exercises using the TBMCS-UL mapping tool. The idea is that facility managers and sweep teams can use the map application as a reporting tool before, during, and after an attack or incident occurs on an installation. Automated chemical and biological detectors also feed into the application. These exercises help commanders streamline recovery efforts and give them realistic expectations of a base's recovery time after an attack.

Whether for threats at home or abroad, the impact of GIS on homeland defense/emergency planning has been monumental since the events of Sept. 11. Regardless of whether GIS tools are supporting active military operations or incidents closer to home, having access to current data, and the ability to analyze the data, saves lives and property. Awareness of these tools/data, in addition to following data standards, can aid in interoperability and decrease duplication of efforts.

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