JSTO in the News

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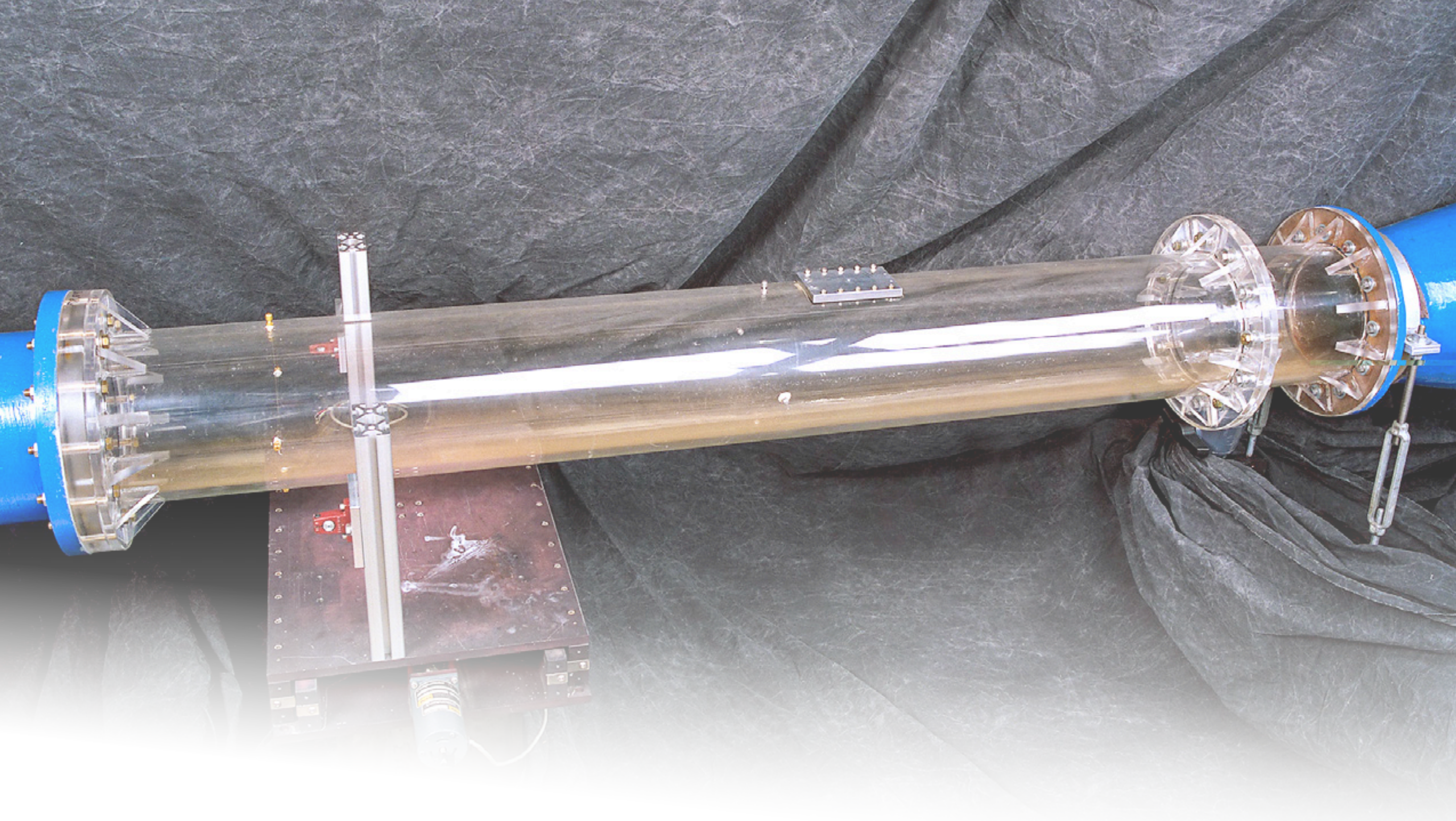
Knowing Which Way the Wind Flows



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DTRA enables the Department of Defense (DoD), the U.S. Government, and international partners to counter and deter weapons of mass destruction and emerging threats.

CHEMICAL AND BIOLOGICAL TECHNOLOGIES DEPARTMENT MISSION

Lead DoD science and technology to enable the Joint Force, nation, and our allies to anticipate, safeguard, and defend against chemical and biological threats.

DEFENSE THREAT REDUCTION AGENCY

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Front cover: U.S Army PFC Seth Gordon participates in the Soldier of the Year Competition held at the Joint Multinational Readiness Center in Hohenfels, Germany. The candidates go through a variety of tests including the Army Combat Fitness Test, weapons qualification, and written tests. (U.S. Army photo by PFC Zachary Bouvier)

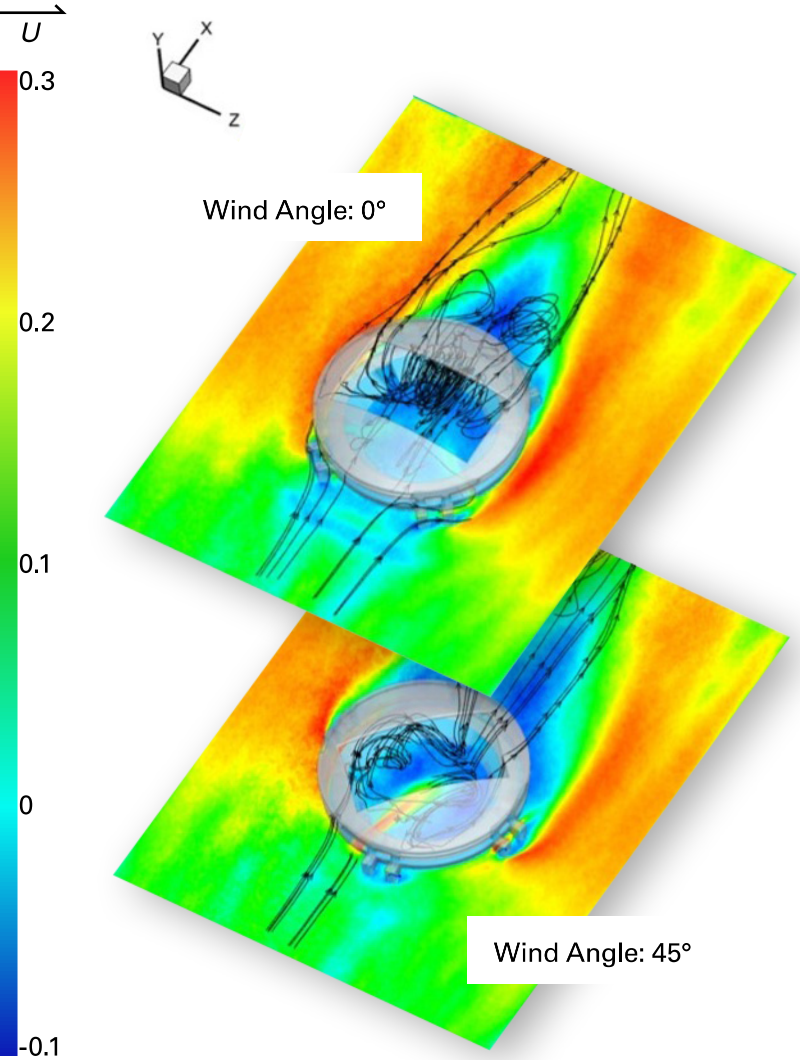
Inside cover: A water tunnel developed and used by NASA. (NASA photo)

Back cover: Yellow smoke disperses into the air during exercise Operation Varsity 19-04. The smoke simulated a chemical attack, adding realism to the exercise that was designed to test airmen's response to chemical, biological, radiological, nuclear, and explosive attacks. (U.S. Air Force photo by Staff Sgt. Devin Boyer)

KNOWING WHICH WAY THE WIND *FLOWS*

Small-scale water channel experiments of urban settings show big results for transport and dispersion models of chemical and biological threats.

Research by U.S. Military Academy cadets and faculty at West Point, New York, showed that the velocity and concentration of a chemical agent dispersed in an urban setting can be measured using a scaled model of a target area submerged in water. The results compared favorably with similar tests done in actual locations, such as the Joint Urban 2003 experiment performed in Oklahoma City. Water channels have been used for decades to simulate airflow around obstacles in low-wind speeds. Many of the computer models that are broadly used today have been validated using data collected from water channel experiments.

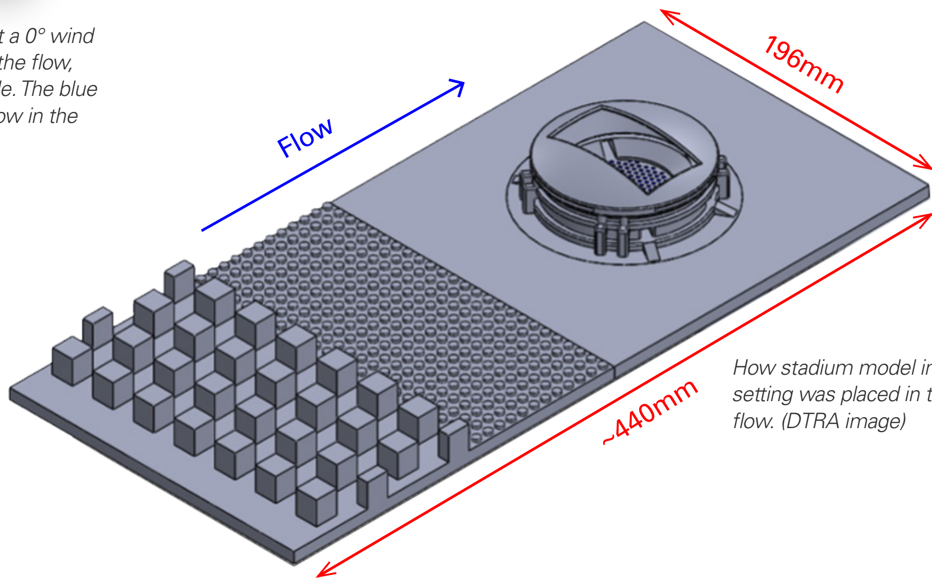


Velocity measurements in meters per second at a 0° wind angle, with the stadium width perpendicular to the flow, and with the stadium rotated to a 45° wind angle. The blue color indicating a negative velocity shows the flow in the opposite of the wind direction. (DTRA image)

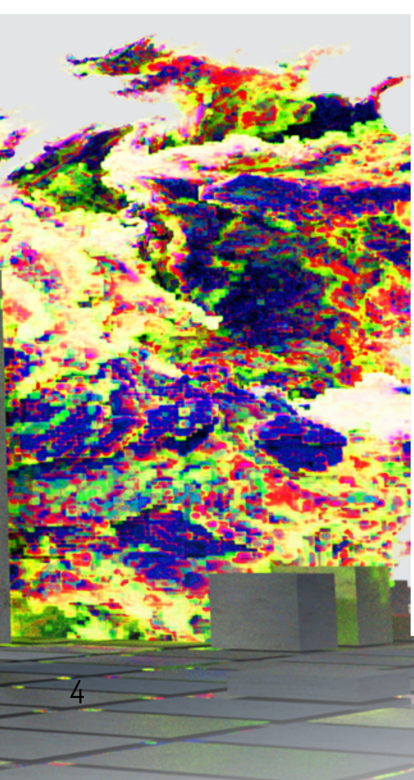
The Defense Threat Reduction Agency's (DTRA) Chemical and Biological Technologies Department in its role as the Joint Science and Technology Office (JSTO) for the Chemical and Biological (CB) Defense Program invested in these studies to understand and validate the transport and dispersion of CB threats in support of DTRA-JSTO's mission to counter and deter weapons of mass destruction and emerging threats.

The West Point researchers at the Center for Innovation and Engineering (CIE) placed a scaled model of an open-air stadium and parking lot near an urban center in a water tunnel, and then placed the water tunnel in a magnetic resonance imaging (MRI) system. They released copper sulfate in the center of the stadium to obtain three-dimensional (3D) measurements of the velocity field and contaminant concentrations.

The cadets' challenge was to build a scale model of a multistory building with entrances, windows, and other openings that allowed for a CB flow to go both around and through one or more buildings, as air would, but in a water tunnel instead. The team conducted the tests and then provided an analysis of results from the MRI-based experiments. An external collaborator helped produce high fidelity simulation results for comparison.

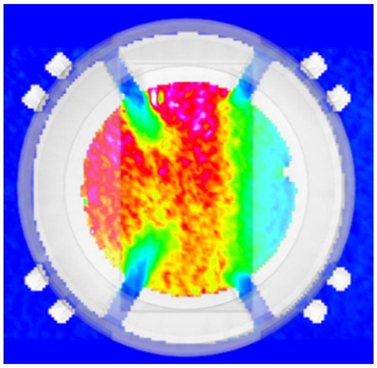


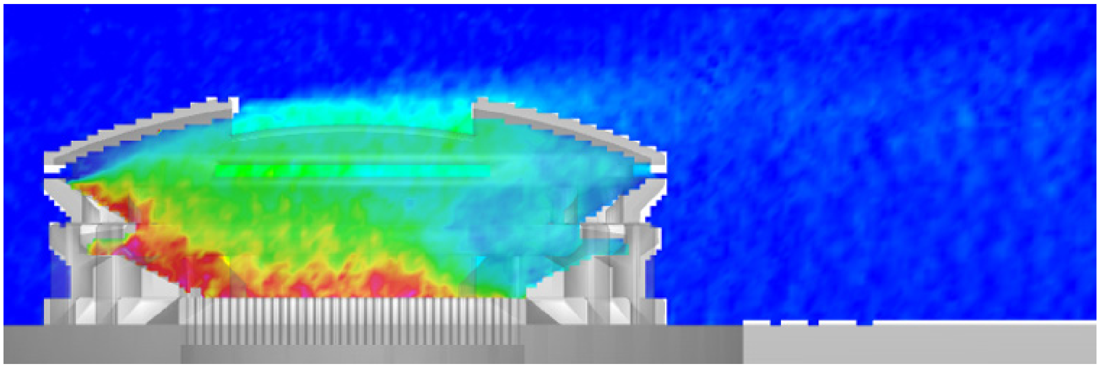
How stadium model in an urban setting was placed in the water flow. (DTRA image)



The cadet team's model was an open circular stadium with ramps to tunnel openings that led to the center of the stadium where noteworthy events like football games or concerts would take place, and with likely security concerns. This stadium design was based on an existing arena but was modified to represent many possible stadium venues. To vary the testing, the stadium could be rotated to allow for several angles of flow. The cadets presented a comprehensive review of their final stadium design, preliminary experimental results, and next steps. This stadium design was then 3D printed and used in the water-flow experiments.

Concentration Measurements at 0° Wind Angle: The red areas show the greatest concentration of the copper sulfate used in the experiment and the dispersion pattern as it flows left to right inside the stadium model. The dark blue (concentration of 0) indicates no contaminant, and the bright pink (concentration of 1) indicates the maximum concentration of contaminant at the source. (DTRA image)





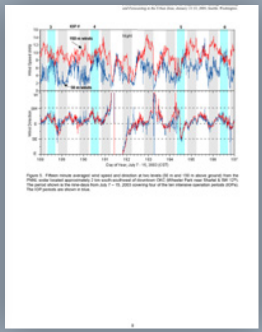
The cadets tested variations in the interior and surrounding flow by altering wind angles from rotating the stadium and using different injection portals with the chemical's dispersion velocity and concentration scans as part of the results.

The team presented engineering analyses using structure data collected from MRI scans of the stadium model, and flow and dispersion simulations using a computer-aided solid-modeling design and engineering program. The team presented their results using several release locations, but they primarily focused on an internal mid-stadium release of copper sulfate, which acted as a neutral simulant mimicking myriad CB threat agents.

The cadets tested variations in the interior and surrounding flow by altering wind angles from rotating the stadium and using different injection portals with the chemical's dispersion velocity and concentration scans as part of the results. For this preliminary study, the velocity measurements included two wind angles, and the concentration measurements focused on one incident wind angle.

The CIE seeks to provide warfighters with comprehensive CB data fusion—the integration of multiple data sources, producing more consistent, accurate, and useful information than that of an individual source—along with analytic capabilities to support situational awareness, decision making, and threat management in a CB-contested environment. This water-flow setup will allow DTRA to conduct other experiments at the small scale for many CB scenarios at a fraction of the cost. This method for producing data will help ensure the models used by warfighters and decision makers are accurate and can be trusted to reflect real-world CB scenarios. ●

ResearchGate



Detailed summary of the extensive tracer/meteorological urban dispersion study conducted during July 2003 in Oklahoma City.

(ResearchGate)

Click here to read the article

POC: Richard Fry, Richard.n.fry.civ@mail.mil

Within the Defense Threat Reduction Agency's Research and Development Directorate resides the Chemical and Biological Technologies Department performing the role of Joint Science and Technology Office for the Chemical and Biological Defense Program. This publication highlights the department's advancements in protecting the Joint Force and citizens from chemical and biological threats through the innovative application of science and technology.

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