



Homeland Security

Science and Technology



# CSAC<sup>TM</sup>

Chemical Security Analysis Center

FY 19

## ANNUAL REPORT

## About the S&T Chemical Security Analysis Center

As part of the Department of Homeland Security's Science and Technology Directorate (DHS S&T), **The Chemical Security Analysis Center (CSAC)** is the nation's only federal study, analysis, and knowledge management center for assessing the threat and hazard(s) associated with an accidental or intentional large-scale chemical event or chemical terrorism event in the United States. S&T CSAC provides an enduring science-based threat and hazard analysis capability with a core focus on six areas of expertise:

- **Risk and Consequence Modeling**
- **Chemical Sensors and Detection**
- **Analytical Chemistry**
- **Chemical Toxicology**
- **Synthetic Chemistry and Reaction Characterization**
- **Non-Traditional Agents and Emerging Chemical Threats**

S&T CSAC serves the broader Homeland Security Enterprise and its stakeholders by continuously staffing and operating a technical assistance program that provides operational support and subject matter expertise; designing and executing laboratory and field tests; and providing a comprehensive knowledge repository of chemical threat information that is synthesized and continuously updated with data from scientific, intelligence, operational, and private-sector sources.



*S&T CSAC supports all six overarching homeland security missions in the DHS strategic plan*

### Diverse Perspectives + Shared Goals = Powerful Solutions

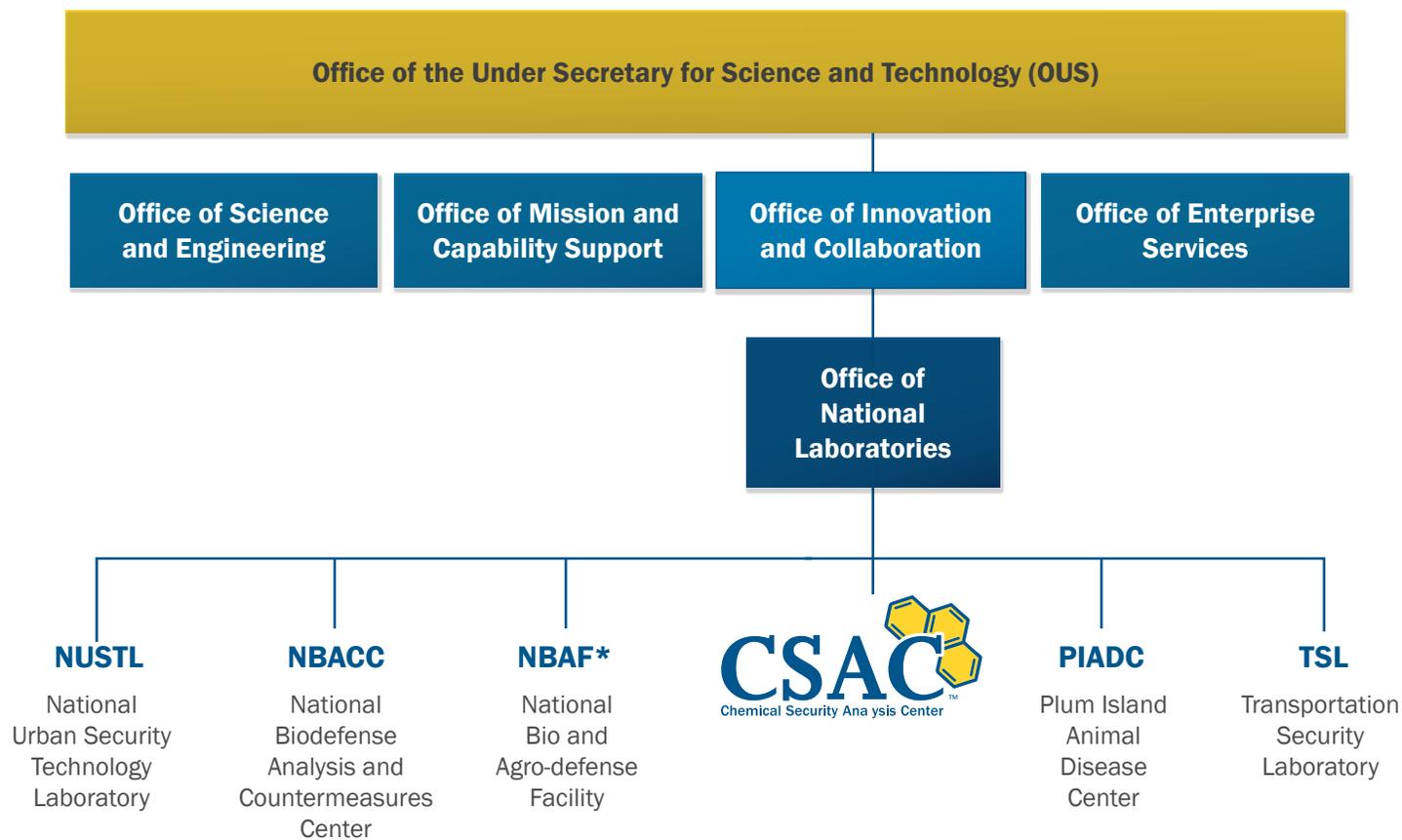
Through a suite of services and products, S&T CSAC empowers a coalition of relevant DHS components, federal agencies, state and local partners, academia, and private entities with actionable risk assessments, threat characterizations, and scientific insights. S&T CSAC's partners use these analyses to shape their planning and decision-making, strengthening the overall security of the United States.

Located in the Edgewood Area of Aberdeen Proving Ground, Md., S&T CSAC fosters research collaborations with the U.S. Army Combat Capabilities Development Command Chemical Biological Center; Department of Defense Joint Program Executive Office for Chemical, Biological, Radiological, and Nuclear Defense; the U.S. Army Medical Research Institute for Chemical Defense; and the U.S. Army Public Health Center.

FY19 CSAC Budget



# Organizational Structure



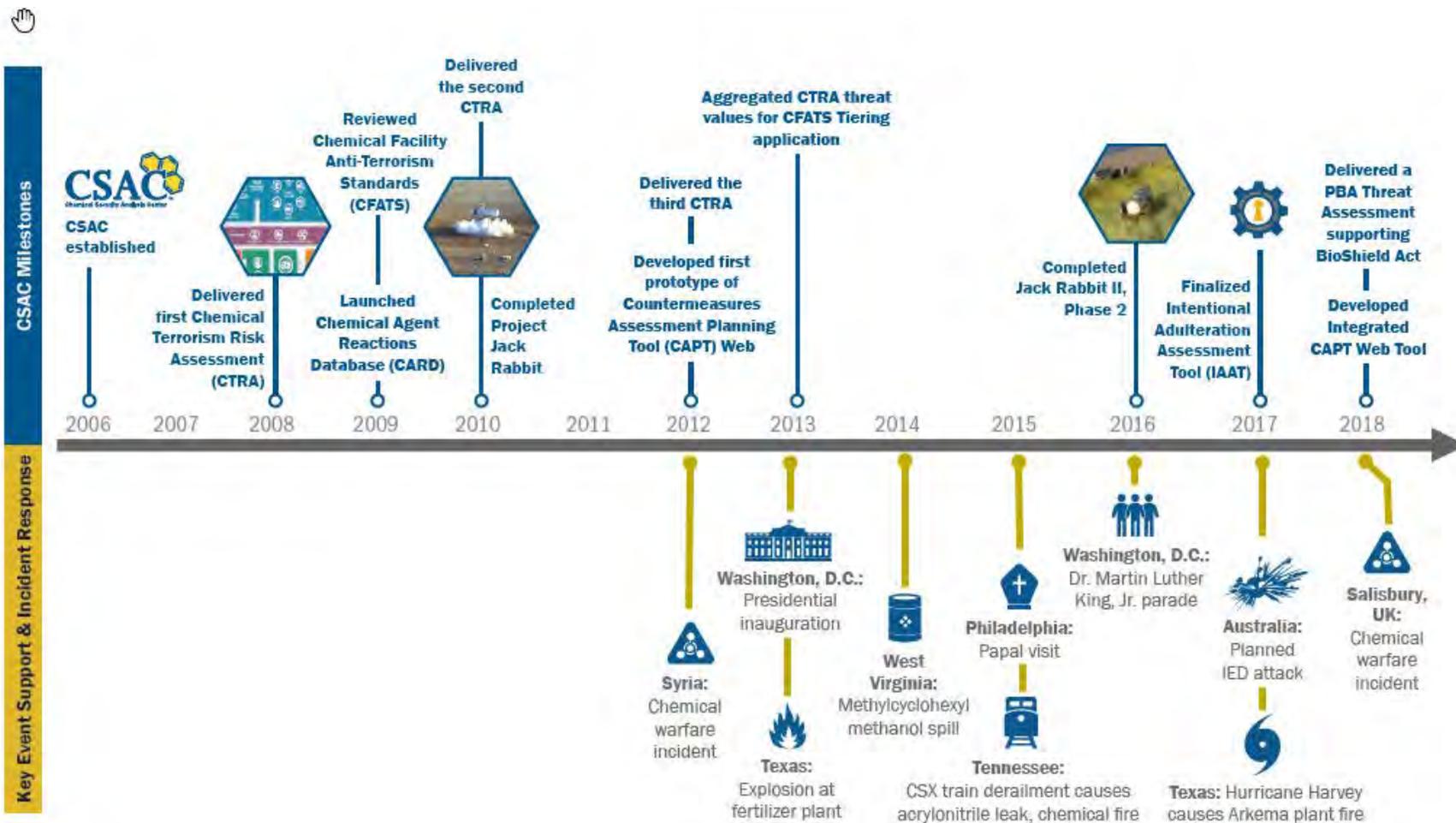
\* In transition to U.S. Department of Agriculture

The **S&T Office of National Laboratories (ONL)** provides a centralized laboratory-based research, development, test, and evaluation (RDT&E) function for the Homeland Security Enterprise under DHS S&T. ONL coordinates a comprehensive network of RDT&E laboratories in service of the homeland security mission, including the five DHS S&T laboratories with capabilities that align with unique Department RDT&E needs.

# A Look Back

Since its establishment in 2006, S&T CSAC's capabilities and tools have evolved to improve the ability of emergency management planners, federal and local first responders, and private sector industry to prepare for, and respond to chemical threats.

With its 24/7 technical assistance program, S&T CSAC stands ready to respond in the event of a chemical terrorist attack, accident, or ongoing crisis. The timeline below depicts several of S&T CSAC's notable accomplishments, as well as its support of key events since its inception.



# 10 SIGNIFICANT FY 19 ACCOMPLISHMENTS



## ASSESSED TECHNOLOGICAL CAPABILITIES FOR ILLICIT DRUG DETECTION

S&T CSAC completed evaluation of chemical detection solutions that U.S. Customs and Border Protection (CBP) could use when processing packages at international mail facilities and express consignment carrier facilities. Current opioid detection technologies and instrumentation were assessed based on their potential as an existing, modifiable, or developmental solution for improving CBP's detection and interdiction efforts. S&T CSAC provided subject matter expertise to DHS S&T's Synthetic Opioid Detection at Speed (SODAS) project and is prepared to assist future efforts.



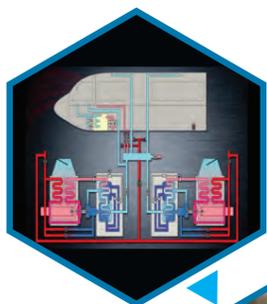
*CBP K9 officer checks mail for contraband at the Miami mail facility in Florida. DHS photo by James Tourtellotte*

### Other Milestones

- Developed an updated Synthetic Opioid Data Repository for fentanyl and 200 synthetic analogs to serve as a vital resource to DHS S&T and the interagency community combatting the opioid crisis. Data include opioid potency, toxicity, median lethal doses, physical properties, analytical data, medical treatment efficacy, supply chain availability, and interdiction metrics and trends.
- Investigated, analyzed, and determined long-term health effects from acute, sub-lethal exposures to opioids, including fentanyl and synthetic analogs.

## 2

### ANALYZED GAS-FORMING REACTIONS TO SUPPORT AVIATION SECURITY



S&T CSAC uses modeling tools and chemical reaction data to improve TSA security measures.

S&T CSAC, in partnership with Transportation Security Administration, Mission Capability and Support (MCS) and the Department of Defense Combatting Terrorism Technical Support Office collaborated with the United Kingdom's Center for Protection of National Infrastructure and the Department for Transport to characterize the impact of toxic chemical releases on an aircraft to inform immediate security measures and explore mitigation strategies. The team of analysts used the Chemical Consequence and Threat Tool (CCAT), part of the Countermeasure Assessment and Planning Tool (CAPT WEB), to calculate the hazard posed from a toxic gas rapidly generated from the reaction of a powder and water. S&T CSAC incorporated MCS-generated experimental reaction data into the models to predict the number of injuries from a release and the time frame in which the injuries would occur. This initial rapid assessment informed TSA security measures related to carry-on baggage. S&T CSAC also worked with international partners to develop higher resolution models for various airframes to better understand key parameters such as airflow within the aircraft, leak paths and location of the device on the aircraft. This joint effort led to a common understanding of

the hazards and impactful masses harmonizing security and detection strategies with key partners, including the UK and EU member states.

Aviation security remains a top priority for the U.S. government, with an interagency working group dedicated to gas-forming reaction (GFR) experimental characterization and modeling. Interagency support is provided by S&T CSAC, the National Counterterrorism Center, Federal Bureau of Investigation, TSA, S&T's Transportation Security Laboratory, Federal Aviation Administration, National Ground Intelligence Center, Combating Terrorism Technical Support Office, and the intelligence community.

S&T CSAC also identified a list of other materials of concern that could function effectively as improvised chemical devices, expanding the focus to include high risk potential threats and developing preliminary data needed to thoroughly evaluate these hazards.

The GFR work highlighted the success of the matrixed organization, leveraging key strengths to provide integrated and comprehensive support to a component and interagency groups responding to an emergent class of threats.

# 3

## PROVIDED HAZARD ANALYSIS OF POTENTIALLY VULNERABLE CHEMICAL FACILITIES WITHIN HURRICANE DORIAN'S IMPACT ZONES

S&T CSAC's 24/7 technical assistance program is available to stakeholders across the broader Homeland Security Enterprise and ensures chemical defense SMEs are always available to provide S&T chemical threat and hazard expertise supporting incident responses and ongoing operations, or to answer other stakeholder requests. In one high profile assistance highlight, S&T CSAC responded to a DHS National Operations Center (NOC) request for information regarding Hurricane Dorian to provide critical chemical facility information and analysis of the toxic chemical hazards and risks within the potential hurricane effect zones. Hurricanes pose a significant risk to even the most secure chemical facilities, with storm-driven power outages, high winds, and flooding potentially leading to chemical leaks, explosions, or fires. S&T CSAC analysis documented the chemical type and the amount being stored at more than 2,000 chemical facilities in the southeastern United States, Puerto Rico, and the Bahamas.



# 4

## COUNTERMEASURE ASSESSMENT AND PLANNING TOOL/CHEMICAL CONSEQUENCE AND THREAT (CAPT WEB/CCAT)



*This graphical representation of the CCAT Tool shows how the six main categories of targets feed into the Medical Mitigation model.*

**184**  
CHEMICALS FOR RELEASE

**37**  
TARGETS

**65**  
STAKEHOLDERS

The Chemical Consequence and Threat (CCAT) Tool is a rapid desktop platform based on models, data, and the calculation engine developed for comprehensive CBRN DHS risk assessments, previously run on a classified computing cluster. The agile CCAT Tool allows users to select from 184 toxic chemicals in its library and calculate the expected lethal and sublethal consequences of a release in a number of different targets including outdoor spaces and indoor soft targets such as a shopping malls or train stations. Contamination targets can also include food and water sources or surfaces similar to the attack in Salisbury, UK, which used a potent nerve agent. The Tool also identifies bottlenecks and resource constraints which impact the ability of the medical system and first responders to deliver care and save

lives during a chemical event. The Tool incorporates the inherent uncertainty of key variables of these attacks (for example mass, attack location, dissemination efficiency, meteorology, medical efficacy), to provide the analyst with a comprehensive picture of the attack and the effect of various strategies and responses. The Tool has been used in conjunction with higher fidelity modeling to provide support to FEMA, U.S. Secret Service, and state and local law enforcement in support of special events or specific mission-based scenarios.

A similar analysis capability exists for biological threats covering 37 agents, including viruses, bacteria, and toxins and well as radiological and nuclear threats covering 14 different isotopes. S&T CSAC has worked with the Hazard Awareness and Characterization

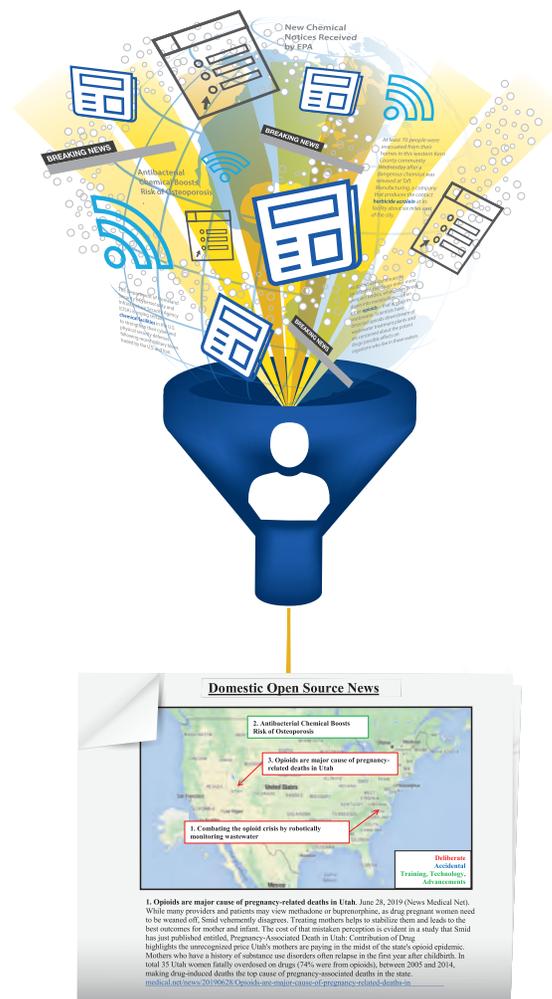
Technology Center (HAC-TC) to develop a comprehensive and integrated platform for users to analyze all hazards, on the premise that a component needs a single place to comparatively assess all types of threats.

The CCAT food modules were also the catalyst for developing the unclassified Intentional Adulteration Assessment Tool (IAAT). IAAT, using DHS-validated data on chemical and biological adulterants applicable to food terrorism, enables food companies to model their processes to identify vulnerabilities and to assess the public health risk of an intentional poisoning. The Tool also includes probabilistic methodology assessing the chances of individuals acquiring adulterants, and the likelihood of accessing each of the steps in a firm’s food manufacturing process.



## INCREASED QUALITY AND VIEWERSHIP OF THE S&T CSAC CHEMICAL CURRENT NEWS REPORT

S&T CSAC's daily Chemical Current News Report compiles open-source information about chemical threats, both domestically and abroad, to the United States and its critical infrastructure. Source content for these unclassified reports is derived from hundreds of links from customized Google RSS feeds that is reviewed by a SME with more than 50 years of chemistry experience, who culls this information and provides context for an insightful report. As a result, many of the articles featured in the report have significant implications that are not recognized by mainstream reporting. This past year, report viewership increased over 38 percent with the addition of 135 customers. Through these Daily Reports, S&T CSAC observes trends over time to determine how chemical defense related areas of concern increase and decrease.



Insightful chemical-related reports culled from hundreds of open source articles.

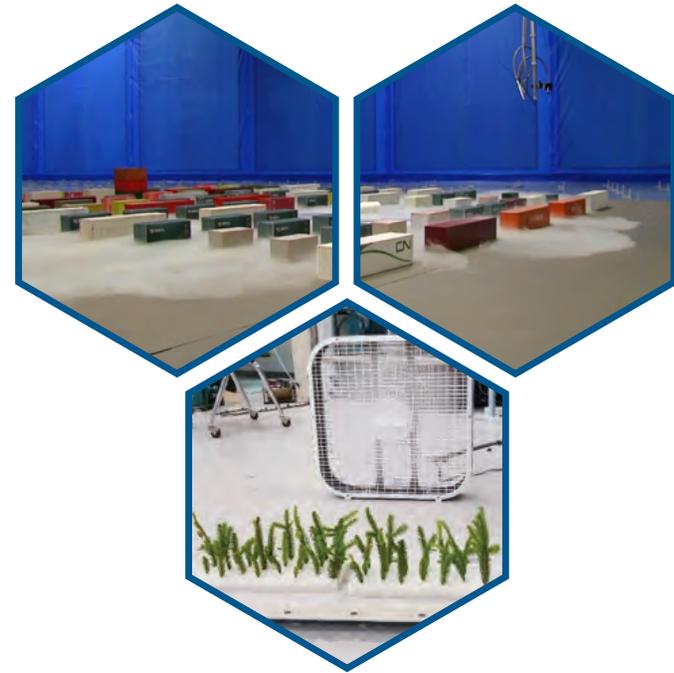


## IMPROVED UNDERSTANDING OF DISPERSION AND REACTIVITY THROUGH CHEMICAL RELEASE STUDIES

To fill data gaps in toxic inhalation hazard (TIH) chemical release modeling, S&T CSAC performs field trials and follow on studies in partnership with the University of Arkansas – Chemical Hazards Research Center (CHRC). In FY19, S&T CSAC studied the potential consequences of a large-scale toxic chemical atmospheric dispersion using physical and computational modeling. Additionally, two programs are ongoing: the Mock Urban Wind Tunnel (MUWT) Program and the Chemical Controlled Environment Reactivity Test (CERT) Program.

In the MUWT Program, a scaled model of the Jack Rabbit II Mock Urban Environment test area was constructed in the CHRC ultra-low speed wind tunnel facility. The major objectives of the Wind Tunnel Task are to conduct wind tunnel experiments for comparison with field-scale releases from the 2015 Jack Rabbit II Tests and to develop guidelines for similar future testing. During FY 19, S&T CSAC and CHRC scientists completed the scaled model, conducted several tests using smoke machines, and made significant progress toward developing video modeling of the field-scale tests.

Meanwhile, the CERT program is assessing whether vegetation can be used to mitigate chemical dispersion following a large-scale release, with the goal of developing accurate



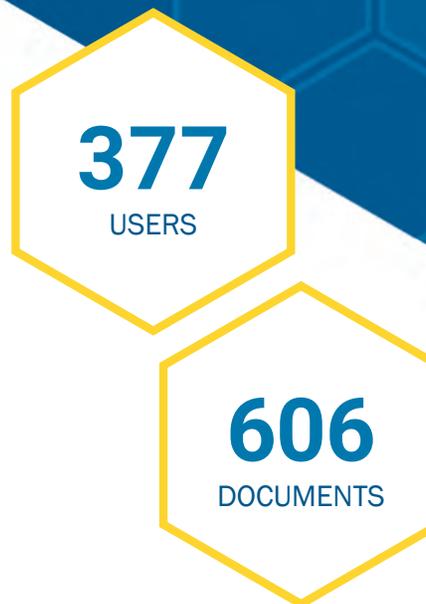
*Wind Tunnel and Reactivity testing at University of Arkansas's CERT and MUWT facilities.*

dispersion simulations that model the chemical absorption of vegetation and soil. To accomplish this, S&T CSAC developed an apparatus to measure chlorine reactivity among various sample vegetation, soil, and other materials under controlled conditions. The team used maple leaves, soil, and grasses to perform numerous chlorine reactivity tests. S&T CSAC will continue to refine this program over the next five years by testing a variety of chemicals, which will eventually enable analysts to perform assessments through simulation and reduce the need for largescale releases like Jack Rabbit I and II.



## EXPANDED THE NTA DATA KNOWLEDGE LIBRARY

S&T CSAC operates the U.S. Government's largest nontraditional agent (NTA) library, featuring 7,000 data points related to the toxicity, properties, and countermeasures for these toxic chemicals. This year, S&T CSAC added 190 documents to the library, which now totals 606 documents. It also increased its federal user base by almost 20%. The classified virtual library includes data matrices and technical documents, such as white papers and material threat assessments (MTAs). This knowledge bank informs several S&T CSAC products and capabilities, including the CAPT Web/CCAT, CARD, 24/7 technical assistance programs, chemical release studies, and other projects. These timely updates ensure researchers, acquisition managers, and policy makers make decisions based on the most recent and complete information available.





*A member of the 21<sup>st</sup> Weapons of Mass Destruction-Civil Support Team, New Jersey National Guard, seals an evidence container at a simulated crime scene during a training exercise. New Jersey National Guard photo by Mark C. Olsen.*



## **RELEASED NEW VERSION OF THE CHEMICAL AGENT REACTIONS DATABASE**

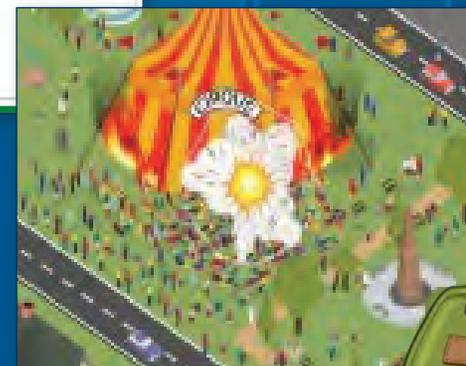
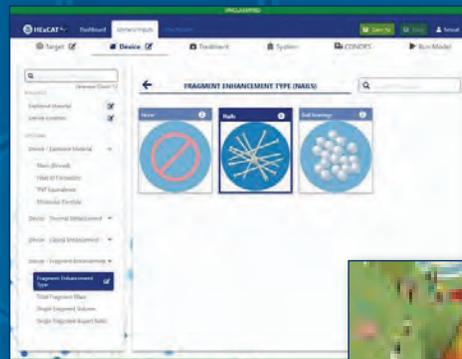
S&T CSAC maintains and reviews extensive data sets related to the synthesis and properties of toxic chemicals, including emerging threat compounds, in CARD. CARD informs S&T CSAC's technical assistance program, consequence and threat modeling, chemical release studies, and features more than 2,000 chemical reactions, both classified and unclassified, providing stakeholders with accurate, comprehensive, and actionable data for chemical threat forensics and attribution. This past year, S&T CSAC made it easier for users to find chemicals of interest by releasing CARD v7.0 and v8.0, adding more than 650 new threat chemicals with 85 new chemical structures, incorporating over 4,000 new chemical property data entries, and adding nearly 4,000 new chemical naming synonyms. These new data enhancements include threat chemicals from S&T mission critical areas, including synthetic opioids and GFRs. S&T CSAC also completed a system unit test on the current release architecture, ensuring search and data accuracy.

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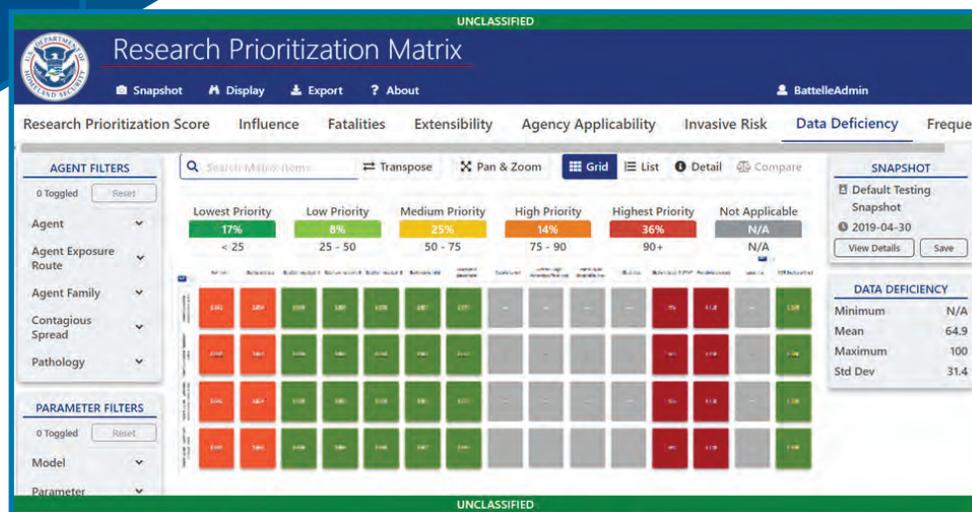
## LAUNCHED BETA VERSION OF HExCAT

Homeland Explosive Consequence and Threat (HExCAT) is a predictive modeling tool that estimates the threat and human health consequences of a wide range of explosive terrorist attack scenarios. The HExCAT informs security investments, operational planning and mitigation. S&T CSAC provided key technical support in development of the Beta version of HExCAT which provides users the capability to model an explosive attack on a variety of interior target spaces, such as office buildings, shopping malls, and subways. Users can modify the parameters of these scenarios to simulate the effects of additional hazards, such as thermal, casing or fragmentation enhancements of the device.

HExCAT also features a medical mitigation model that simulates the first responders' role and the medical system's response to an explosive event. The medical mitigation model progresses victims through the medical response process including onsite triage, transportation to medical facility, and application of life-saving treatments. By capturing the severity of the injuries and tracking the personnel, countermeasures, and facility resources throughout the simulation, users can identify potential chokepoints in the system and apply targeted improvement to concepts of operation and usage of resources. This enables the analyst to identify and explore alternative concept of operations as well as the impact of new resources or initiatives.



*HExCAT estimates threat and consequences of, and informs investments against, explosive terrorist attack scenarios.*



The prioritization matrix ranks chemical risk data gaps, aiding decision makers.

## KICKED OFF THE DEVELOPMENT OF THE RISK PRIORITIZATION MATRIX

To help decision makers prioritize research goals and funding, S&T CSAC launched Phase I of the Chemical Risk Prioritization Matrix (RPM). Many thousands of input values in areas such as toxicity, medical mitigation, chemical and physical properties, and ease of production are needed to run the DHS chemical risk assessments. The RPM will identify key parameters based on risk, sensitivity of risk to that parameter, level of confidence in that particular parameter, and the influence of that parameter on other elements in the risk assessment. Data gaps will be ranked based on these factors to ensure that a systematic, defensible process is used to recommend funding for the highest value and most impactful research programs.

This past year, SMEs developed a process to evaluate data quality for key parameters in the areas of toxicity, medical mitigation, chemical and physical properties,

and organoleptics, which is fundamental to the RPMs long term success. A scoring rubric was developed for the model parameters, ranging from assessing the type of animal model and conditions used to derive toxicity values, or the suitability of a chemical surrogate to estimate solubility or vapor pressure. Moving forward, more than two dozen SMEs from S&T CSAC, U.S. Air Force Research Laboratory, U.S. Army Public Health Center, U.S. Army Medical Research Institute of Chemical Defense, U.S. Army Combat Capabilities Development Command-Chemical Biological Center, U.S. Department of Health and Human Services, National Institute of Standards, American College of Medical Toxicology, and DHS Countering Weapons of Mass Destruction will work collaboratively to establish data confidence criteria and evaluate data confidence for an initial representative set of chemicals.





## Mission

Collect, consolidate, curate, store, and share **chemical data**



Generate **meaningful assessments, recommendations, and forecasts** based on vetted data



Identify, prioritize, and address data gaps through **high quality chemical RDT&E**

## Core Expertise

- Risk and Consequence Modeling
- Chemical Sensors and Detection
- Analytical Chemistry
- Chemical Toxicology
- Synthetic Chemistry and Reaction Characterization
- Non-Traditional Agents and Emerging Chemical Threats



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