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The Development and Use of the *Food and Agriculture Systems Criticality Assessment Tool (FASCAT)*

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ABSTRACT

After the terrorist attacks of September 11, 2001, the United States (U.S.) government established a policy to identify critical infrastructure, including food and agriculture production systems, to protect them from terrorist attacks. Criticality is defined as the negative impact of an attack on or failure of a given infrastructure on the nation if it were compromised or destroyed. Food and agriculture systems were identified as one of 18 critical infrastructures. Identifying which food systems were the most critical to the nation was an enormous task, since the food and agriculture sector is almost entirely privately owned, is comprised of an estimated 2.1 million farms, has over 1 million production facilities, and accounts for roughly one-fifth of U.S. economic activity. To assist the Department of Homeland Security in determining which food systems were the most critical to the nation, the National Center for Food Protection and Defense developed the Food and Agriculture Systems Criticality Assessment Tool (FASCAT) to support states' identification of critical systems. The FASCAT was used to document, evaluate, and compare 741 disparate complex food and agriculture systems across 39 states to determine their criticality. The objective of these assessments was to prioritize the allocation of threat mitigation resources to the most critical systems. Prior to the use of FASCAT, no food and agriculture systems were identified as critical in the U.S. Now, with the use of FASCAT, many food and agriculture systems have been added to the criticality list. This article discusses why the FASCAT was built, how it has evolved, and how the process currently works.

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INTRODUCTION

In 2003, the Homeland Security Presidential Directive 7 established a national policy for federal government departments and agencies to identify and prioritize United States (U.S.) critical infrastructure and key resources to protect them from terrorist attack *(2)*. The food and agriculture sector, is one of eighteen critical sectors that is almost entirely privately owned and is composed of an estimated 2.1 million farms, approximately 880,500 companies, and over 1 million facilities, accounts for roughly one-fifth of the U.S. economic activity *(7)*.

The 2009 National Infrastructure Protection Plan states that the government and the private sector are jointly responsible for protecting complex, globally distributed, and highly integrated components of food and agriculture systems *(6)*. This declaration was made because of a widespread concern that the food system could be used as a vehicle to poison, maim, or kill thousands, if not hundreds of thousands, of people or result in significant economic harm. The joint responsibility for protecting food and agricultural systems requires a partnership between the government and private sector to identify critical assets. Criticality is defined as the negative impact that the destruction of a critical infrastructure would have on the nation if it were destroyed *(17)*. Protecting critical assets, which requires first identifying which food and agriculture systems are most critical, is essential *(4)*. Furthermore, it is vital to determine which systems are most essential in terms of consequences to public health (both psychological and physical), the economy, and the government.

The Food and Agriculture Government Coordinating Council and Sector Coordinating Council (GSS/SCC) partnered with one of the Department of Homeland Security's (DHS) Centers' of Excellence, the National Center for Food Protection and Defense (NCFPD), to develop an assessment tool to assist states in determining and documenting the most critical elements, sub-systems, and systems within food and agriculture infrastructure *(6)*. The tool developed by NCFPD, called the Food and Agriculture Sector Criticality Assessment Tool (FASCAT), provides state officials responsible for protecting food and agriculture with: (i) a means to identify systems that are critical to each state's commodity supply chains and food distribution systems; (ii) a method to prioritize state or private sector vulnerability assessments and protective measures for asymmetrical threats to food and agriculture systems (iii) documentation and improved characterization of each state's food and agriculture systems' risk profile; and (iv) a method to provide critical food and agriculture infrastructure component information to DHS's National Data Call.

States generally do not have system-specific data on all the elements of the food and agriculture infrastructure as they do for many other critical infrastructures (e.g., nuclear reactors, government facilities, and dams). While most food and agriculture facilities are inspected, licensed, and regulated by multiple state and federal government agencies, they are owned and operated outside of the government *(16)*. Consequently, establishing partnerships across state agencies and with the private sector is the only way to successfully and completely characterize the food and agriculture infrastructures so as to assess and determine which infrastructure systems are the most critical. FASCAT is a consequence and system characteristics-based assessment that provides a comparative analysis of vastly disparate systems, sub-sectors, and sub-systems (e.g., comparing the criticality of the fluid milk system to the potato system) *(18)*. Realizing that FASCAT was not developed as a stand-alone risk assessment or vulnerability assessment tool is important. Traditional risk and vulnerability assessments typically focus on individual facilities in the food production system, and the results of these assessments do not enable the user to make comparisons between systems. FASCAT considers a multitude of factors so as to enable users to determine which systems should be prioritized for vulnerability assessments, implementation of protective controls, risk mitigation, and emergency response planning.

To be successful, state officials must engage with representatives from multiple government agencies and privately owned food systems operators who have direct working knowledge of food and agriculture infrastructure to obtain the necessary information to complete criticality assessments *(13, 15)*. Required collaborators may include agencies responsible for agriculture (e.g., inspection program leads, emergency response leads), animal health experts (e.g., state veterinarians), environmental scientists, public health professionals (e.g., environmental inspectors, foodborne illness outbreak traceback and traceforward investigators, epidemiologists), transportation managers, law enforcement personnel, and homeland security representatives *(9)*. Representatives from the private sector or from associations that represent the food production systems must be involved in the criticality assessment process, and the criticality assessment team should include the companies that own the food system being evaluated (e.g., farm bureaus, animal agriculture associations, food processing associations, etc.) *(10)*.

The information generated by FASCAT enables the owners and operators of food and agriculture systems to coordinate and collaborate with each other, as well as enabling state and federal government agencies to assist in protecting these critical infrastructures. Based on NCFPD's evaluation of FASCAT use, the most efficient approach to obtaining the necessary representatives from the government and private sector is to have state governments lead the effort *(11)*. In situations in which the state officials are not familiar with the food and agriculture systems in their state, the first step to successfully completing a FASCAT assessment is to conduct a training session with all of the appropriate government and private sector leaders to familiarize them with the assessment and to review their available food and agriculture systems' data. Meeting with SMEs and participating in a FASCAT training session may not be required if the state officials already have detailed knowledge of the food and agriculture systems in their states. After food and agriculture system data has been updated or added to FASCAT, the second step is to host a working session to populate FASCAT to determine an initial characterization of the infrastructure and to assess what is most critical in the state. Through the use of FASCAT, the sector owners and operators, the states, and the nation have been able to identify which systems are most critical, and why, in the food and agriculture sector. The information gained through engagement and FASCAT analysis allows for security resources to be focused on increasing the protection of the most critical systems from man-made, natural, or accidentally occurring threats *(14)*. When implemented, these efforts will assist in reducing the probability of

successful use of the food system as a weapon to attack our nation, increase our ability to rapidly identify threats to complex food systems, and assist in recovery to normalcy in the event of a successful attack *(12)*. While an early, limited application, spreadsheet-based version of the tool is available to the public on the NCFPD webpage (FASCAT Version 2.0), the more advanced, comprehensive, and easy-to-use interface version of the FASCAT (Version 3.0) is available only through the protected and secure FoodSHIELD web portal. FASCAT Version 3.0 resides in FoodSHIELD because the intended users are state agencies, to prevent unauthorized or malicious people from accessing the potentially sensitive data and to protect the confidentiality of the owners' data.

FASCAT OVERVIEW

FASCAT has been used by 39 states to determine and compare the criticality of food systems within their jurisdictions and has been used most heavily by states that contain high proportions of the nation's food and agriculture systems *(11)*. During the FASCAT process, each state's food official(s) gathers the subject matter experts (SMEs) for each commodity within their state (e.g., milk, eggs, grain, frozen pizza, pasta sauce). Often the SMEs are employees of the companies that own the food system being evaluated or regulators from state or local government agencies. Typically, SMEs are the best source of information related to prioritization of food system and production risks *(1)*. First, the state officials ask questions provided by the FASCAT to the SMEs (e.g., the type of food system, threats, consequences, impacts of disaster, probability of the threats, footprint of a disaster). After SMEs are asked questions, the SMEs debate among themselves until a consensus can be obtained for each commodity and question in the FASCAT. When consensus is reached, the state official responsible for food and agriculture protection records the agreed-upon answer in the FASCAT software. As the answers are recorded in FASCAT, the commodity's criticality score is calculated by the software and is displayed as each question is answered, until all of the questions in FASCAT are completed. Typically, the first FASCAT assessment takes state officials and industry SMEs approximately 3 hours to complete. Subsequently, as familiarity and proficiency with the FASCAT methodology increases, assessments typically take an hour or less. Despite the opportunity cost associated with learning the FASCAT, it has been used in over 741 food systems criticality assessments throughout the U.S.

FASCAT version 1.0 & 2.0

FASCAT has been revised twice since it was first developed. All versions were developed in cooperation with food industry, government, and academic SMEs. FASCAT Version 1.0 and 2.0 were constructed using a commercially available spreadsheet and collected food systems characteristics data (e.g., commodity type, threat profile, state government point of contact, etc.), which would generate a score on an ordinal scale between 0 and 200. The score generated by FASCAT 1.0 enabled state officials to compare disparate food systems so as to be able to select systems to protect first. Then, the scores could be used to prioritize vulnerability assessments, protective measures, and threat mitigation strategies. FASCAT Version 1.0, which was used for 2 years, was decommissioned after the development of FASCAT Version 2.0. Retrospectively, these data collected by FASCAT Version 1.0 did not meet the requirements of measuring criticality because of the inclusion of broad generalizations and lack of variation in threats and consequences. Later, in FASCAT Version 3.0, threats and consequences were more clearly defined and accounted for all the elements that SMEs believed to contribute to food and agriculture systems' criticality. The lack of operational definitions of key terms in FASCAT 1.0 probably contributed to poor inter-rater and test-retest reliability and increased the potential or facilitator/trainer bias; however, the development of that first version of FASCAT enabled state governments to begin thinking critically about their food and agriculture production systems. The lack of sufficient variability in food system characterization in Version 1.0 (e.g., system description, threats, consequences, and vulnerabilities) reduced the users' ability to discriminate effectively between disparate systems. Version 2.0 had many new additions and revisions (i.e., additional commodity flow charts, enhanced threats, consequences, and vulnerabilities); these enhancements to FASCAT enabled users to characterize food systems adequately and enabled FASCAT to better discriminate between closely related food systems. As a result of these improvements, FASCAT was better able to identify which food systems were the most critical to the states.

FASCAT version 3.0

In 2010, the FASCAT received many updates and revisions, partly to minimize the immense data-reporting burden on state government agencies and to remedy the difficulty in manipulating FASCAT 2.0's spreadsheets. During FASCAT 3.0 development, FASCAT's users (state officials) were required to continue their annual submission of data to the DHS's Office of Infrastructure Protection (IP). To comply with IP's Annual Data Call, state governments are required to report critical infrastructure information to IP on all 18 critical infrastructure sectors, and the reporting of critical infrastructures information is a monumental and time-consuming task to state officials. NCFPD sought to minimize the burden on state officials of reporting food and agriculture critical infrastructure information to DHS through FASCAT. FASCAT 3.0 was able to overcome the challenge of assembling complex and analogous data consistently by developing a single software platform for identification, analysis, and comparison of systems' criticality for the state's submission to DHS. FASCAT 3.0 software provided a standardized format for identifying, collecting, and recording food systems data, a process for converting recorded data to a standardized reporting format, and a method of characterizing and calculating food systems criticality.

Taxonomy

One of the problems in reporting data to the federal government is that varying federal agencies use different terminology and taxonomy to describe food and agriculture production, making it difficult for state officials to determine the correct terminology for reporting to each federal entity. The U.S. government's data reporting requirements led to the development of resources such as the Infrastructure Data Taxonomy (IDT) and the Infrastructure Data Collection Application (IDCA) tool *(5)*. The IDT standardized the language used to describe critical infrastructures for the state governments, and the IDCA made the transfer of information from states to IP easier. To compare similar infrastructures, IDT was developed by IP to ensure that similar

infrastructure components were identified similarly between states (e.g., maize processing and corn processing). By using a common system of terminology and method for categorizing information, the IDT allows critical infrastructure data to be more easily compared and contrasted by the federal government. FASCAT uses the IDT to ensure consistent use of terminology between state and federal agencies in identifying the food system being evaluated for criticality. Thus, state officials needed only to identify the system in FASCAT, which then translates the selected food type to the terminology used by each federal entity. This FASCAT upgrade ensured that all parties involved were using similar nomenclature, saved government entities time, and was essential to effectively determining food and agriculture criticality.

Data reporting

NCFPD further reduced the burden on state officials by enabling FASCAT Version 3.0 to create IDCA reporting forms for state officials. As users complete the FASCAT assessment, the IDCA preamble, assessment, and justification scenario is created under the IDT taxonomy. In Version 3.0, the user can then download the finished IDCA document. This helped state officials collaborate with the sector-specific agencies or state and territorial homeland security advisors to nominate their food and agriculture systems for selection as a DHS Level 1 or Level 2 Critical Infrastructure Key Resource (CIKR) asset. In some cases, the nomination as a DHS Level 1 or 2 CIKR asset resulted in the federal government's assistance in securing the asset by providing additional security resources. The ability of FASCAT 3.0 to generate the IDCA report saved the time of many state government agencies and food defense managers by quickly characterizing their food systems' characteristics and threat profile and then providing the characteristics in the IDCA reporting format.

Data collection

FASCAT was converted from a spreadsheet-based tool to a web-based graphic user interface (GUI) to ease the collection of data, to improve the quality and consistency of the data collected, and to make the entry of data more intuitive for the FASCAT's users. Additionally, more detailed commodity flow charts that illustrated the food system supply chains and manufacturing processes were included as a reference in FASCAT Version 3.0 to assist state officials in identifying, characterizing, and evaluating the criticality of food systems in their jurisdictions.

State officials collect data on a wide array of food systems and also collect the system operators' contact information. The collected information is used to calculate and compare systems criticality and to develop an emergency contact list. Also, the data collection process of FASCAT fosters communication between the private sector systems operators, commodity specific subject matter experts (SME), and state officials, and is essential for rapid and effective communication with the food industry in case of an intentional contamination event *(8)*. While the ability to characterize food systems is important for determining food and agriculture systems' criticality, having a unique, independent, and secure database of food systems owners and operators helps facilitate communication between the private sector and state officials in the event of unintentional or intentional contamination of food systems *(3)*. By establishing relationships with SMEs and systems owners and operators, and by collecting and storing their contact information through FASCAT, people responsible for food defense are able to rapidly identify and communicate with the necessary people during unintentional or intentional food contamination events.

System characterization

To characterize the criticality of a system, FASCAT collects information detailing the food product types within the system. These food products could be processed foods such as canned vegetables, pasta sauce, or frozen pizza, or they could be minimally processed foods such as fresh produce, chicken broilers, or ground beef. During this step in the FASCAT process, the number of facilities in the supply chain is recorded from farm to fork. This information can be useful for estimating the size of the system in combination with other factors and data collected in FASCAT. After the system being evaluated is identified in FASCAT, the program uses this information to weigh the criticality score. The weighted criticality score may be useful in differentiating systems criticality by spreading out the distribution of scores; however, FASCAT also calculates a cumulative criticality score in which weighting by commodity type does not occur. This allows the state official responsible for food and agriculture defense to give preference to theoretically risky or fragile systems, or to compare systems without a prior knowledge, using the cumulative score. In either case, FASCAT provides a means to compare the criticality of disparate systems.

Criticality scoring

After the type of system is identified and recorded in the database, FASCAT utilizes an all hazards approach to determine systems criticality. Specifically, FASCAT enables the users to examine and determine the likely threats, initial consequences, 2nd and 3rd order consequences, and impacts of an attack or disaster on the system. In FASCAT, the users are able to select multiple possible threats to the system being evaluated (e.g., foreign animal disease, chemical/toxin, plant pests, pathogen contamination, cyber threat). As each threat is selected, points are added to the cumulative criticality score; the number of points assigned for each threat is based upon the severity of the threat to the selected commodity (e.g., if fluid milk was being evaluated and chemical/toxin was selected, the cumulative score would increase by 3). Threats that are not plausible for the selected commodity are inactivated by the software and cannot be selected. For example, if fluid milk is the system being evaluated, a user cannot select plant disease as a primary threat, and this restriction prevents users from gaming the tool by selecting all of the threats to the commodity to increase the food system's criticality score. After the threats are selected, the users may justify their threat selections or provide any additional pertinent information in an open text comment box. Similarly, the user repeats this process for consequences (e.g., loss of tourism, long-term shutdown, economic loss, mass human casualties), and 2nd and 3rd order consequences (e.g., damage to tax base, disease spread to others, loss of public confidence); the selection of these factors increases the cumulative and weighted scores. The process of selecting the impacts of the attack or disaster is similar to the previously described threat selection process (e.g., greater than 1 year to recover, at least 10,000 human casualties, more than 5 states impacted); however, the factors selected have a multiplicative

effect on the weighted score, which measures the size of the footprint of the consequences and helps determine if the food and agriculture system meets the criticality thresholds regulated by the DHS Homeland Infrastructure Threat and Risk Analysis Center (e.g., *when a specific food system* is being evaluated and *10,000 human casualties* is selected and *more than 5 states impacted* is selected under impacts, the weighted score increases by 1.75 times). The cumulative and weighted scoring process within FASCAT is completely transparent, as each manipulation of any factor simultaneously changes the scores and the scores are continuously displayed.

After these data are collected, FASCAT prompts the user for information on the ease of attack (i.e., low, medium, high), probability of disaster (i.e., low, medium, high), scale/size of component at risk (i.e., small, mid-size, large, very large, more than 5 states), recovery/return to normalcy (e.g., less than 3 months to not probable), and concentration (i.e., highly concentrated, moderately concentrated, dispersed within a region, widely dispersed, less than three total components). All of these data contribute to the criticality score in an additive fashion. The ability to collect these types of data on complex food systems and characterize food systems in terms of their unique threats, consequences, and impacts enables FASCAT to compare the criticality of disparate food systems on an ordinal scale.

CONCLUSION

The NCFPD developed the FASCAT to assist states in objectively determining which food systems were the most critical to the nation, to protect these systems from terrorist attacks. Since FASCAT was developed, it has been used in over 741 criticality assessments in 39 states to identify, document, evaluate, and compare disparate complex food systems, which has resulted in addition of multiple food and agriculture systems to the DHS critical infrastructure list for the first time in history. Some of the food systems analyzed with FASCAT received additional resources from DHS to mitigate potential food defense threats. FASCAT enables its users to determine systems' criticality and then prioritize the allocation of food defense resources or threat mitigation strategies.

FASCAT has several limitations. First, the use of subject matter expertise to determine probability of threats, vulnerabilities, consequences, and the magnitude of systems failures needs to be validated. The probability of large-scale naturally occurring threats (e.g., hurricanes and floods) can be determined using more objective methods (e.g., spatial risk analysis) instead of relying on the subject matter experts' subjective opinions. Potentially, the group consensus method used in FASCAT was biased by groupthink or influenced by subject matter experts with strong personalities. If future research discovers that these two limitations of FASCAT substantially affect the outcomes of FASCAT analysis, then alternatives to the use of subject matter experts to quantify criticality need to be explored.

Despite FASCAT's limitations, FASCAT cannot be conventionally validated without a series of catastrophic events. Instead, the FASCAT data can be used to determine FASCAT's reliability, construct validity, content validity, and internal validity. Fortunately, the broad use of FASCAT across multiple production systems, commodity types, and geographic areas allows the collected data to be analyzed and tested. The ongoing analysis of the FASCAT process and data will help determine if the FASCAT methodology is valid and of value to its users. Even though FASCAT has not yet been empirically validated, NCFPD has continued to make improvements to FASCAT on an ongoing basis in an effort to better meet the food defense needs of state officials and the private sector. Future research must be conducted to determine if the FASCAT methodology is a reliable measure of criticality and to determine if bias or significant sources of error exist in the FASCAT process. Although FASCAT has imperfections, it has greatly helped the federal and state governments identify critical food and agriculture systems as part of how they dedicate precious resources to protect them from adverse events.

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