MEETING RECAP

FOOD SAFETY AND NATIONAL DEFENSE

A WORKSHOP HOSTED BY THE GOVERNMENT-UNIVERSITY-INDUSTRY RESEARCH ROUNDTABLE

September 29-30, 2009

This meeting recap was prepared by National Academies staff as an informal record of issues discussed during the September 29-30, 2009 meeting on "Food Safety and National Defense". The document is for information purposes only and supplements the meeting agenda available online at www.nas.edu/guirr. It has not been reviewed and should not be cited or quoted, as the views expressed do not necessarily reflect the views of the National Academies or members of GUIRR.

In February of 2009, members of the Government-University-Industry Research Roundtable (GUIRR) met in Washington, DC, to consider the role of inter-sector partnerships in helping to accelerate the path to solutions in safeguarding the nation's food supply ("Perspectives on the 'Global Food Crisis'"). Subsequent to that meeting, a small food safety working group was established with a specific objective in mind: To engage senior science, technology and policy personnel from companies, the federal labs, government agencies, and research universities in an open dialogue to:

1. *highlight critical opportunities for maintaining U.S. national defense, focusing on food and the supply chain; and*
2. *foster new collaboration among participants, all of whom possess, manage, and/or oversee particular capabilities, including knowledge, available technology, and/or fundamental research, in the food safety and national defense area.*

A workshop based on these objectives was held on September 29-30, 2009 at the National Academy of Sciences in Washington, DC, hosted by GUIRR. The intention was to explore the potential for companies and universities to work with the national labs – notably those that have declared homeland security as a mission – in redirecting current technologies to help safeguard the nation's food supply. The workshop served as a forum for candid, cross-sector discussion and the identification of areas ripe for innovation and collaboration. A recap of the workshop follows.

SETTING THE STAGE

Dr. Harold Schmitz, Chief Science Officer of Mars, Inc., and **Ms. Margaret Bruce Saunders**, Homeland Security Director of Oak Ridge National Laboratory, opened the workshop, stressing that government, universities, and industry must work together, and not fragment, to counter food supply chain threats. Food safety is important to homeland security.

Security in food safety, they explained, can be looked at in two ways: 1) using the traditional sense of the word, in terms of people having the nutrition required to have a secure livelihood; and 2) using the modern sense of the word, in terms of how to keep food supply chains secure and minimize threats. In terms of keeping the supply chain safe, there are a lot of capabilities and dormant assets not being utilized for food safety and security, including the national laboratories, which represent important infrastructure. Beyond the national laboratories, we can examine food supply chains from the point of view of the end user, the front end, and the middle.

The end user includes the food industry, which represents users of technologies that help make and put into the marketplace safe food products. The technologies employed by the food sector, however, are not as modern as they could be. There are some specific instances where it is clear that the best technology was not in place to help keep the food supply of the United States safe and secure. Furthermore, there are specific areas, in the industry, of potential risk where modern technology implementation could be especially welcome. The front end is science and technology development that, with massive capability, leads to specific applications for the end user. It is important to think about what is needed in order for that science and technology to lead to useful applications. The equally important middle represents large industrial players, such as 3M and IBM, who help commercialize these technologies. If there is no one to commercialize, or make real in a business sense, then no matter how good a technology is on the front end and no matter how much the end users in the food industry might want it, none of this will occur.

Schmitz and Saunders posed two questions to help guide discussion: 1) In addressing the safety and security of our food supply, what is the target? and 2) Which science and technology policies will help insure that the best technologies are applied to keep our food supply safe and secure? In their view, neither of these questions has been directly addressed before. Collaborations between the private sector and national laboratories, such as Mars, Inc. and Oak Ridge National Laboratory, can illuminate this discussion, they stated, but it is also essential to hear from the federal agencies.

PERSPECTIVE OF THE FEDERAL GOVERNMENT

Next to speak was **Dr. David Goldman**, Assistant Administrator with the Office of Public Health Science at the USDA’s Food Safety Inspection Service (FSIS), a part of the Public Health Service. Goldman’s office is responsible for all risk assessments, regulatory laboratory work, and outbreak investigations conducted by the USDA. FSIS is a public health regulatory agency that has a major role in the farm to table food safety system, based on statutory requirements from the Federal Meat Inspection Act, Poultry Products Inspection Act, and Egg Products Inspection Act. FSIS ensures that meat, poultry, and processed egg products are safe, wholesome, and accurately labeled and packaged along the entire farm to table continuum. Research for FSIS is conducted by the Agricultural Research Service, which provides direct assistance to FSIS.

Goldman described the research priorities of FSIS:

- Ecology/epidemiology of foodborne pathogens throughout the farm to table continuum
- Pathogen modeling
- Methods for detecting and characterizing human foodborne pathogens
- Management practices and interventions to reduce pathogens
- Chemicals, toxins and veterinary drugs
- Consumer behavior

FSIS has not had significant interactions with the national labs, although some collaboration is occurring (for example, Lawrence Livermore risk assessment of catfish, which will soon come under FSIS regulatory authority). One area where there could be collaboration between FSIS and the national labs, according to Goldman, includes developing methods to detect chemicals in food matrices. FSIS is charged with conducting periodic baseline studies to look at the presence and levels of pathogens in various food products. FSIS could partner with the laboratories in developing a baseline, looking for unknown pathogens or microbial contaminants in foods.

Dr. LeeAnne Jackson, a member of the Food Defense Oversight Team in the Center for Food Safety and Applied Nutrition of the US Food and Drug Administration, followed with an overview of the needs and challenges in food defense research. Highlighting those areas that could be grounds for collaboration with government, industry, and university partners, Jackson identified six specific areas in primary food defense in need of further research and development:

- New Methods
- Prevention Technologies
- Agent Characteristics
- Dose-Response Relationships
- Sampling
- Modeling, Simulation, and Analysis

According to Jackson, we need the development and validation of new field methods for the detection of microbiological and chemical agents, new laboratory-based confirmation methods and the techniques for fingerprinting agents, the technology transfer of field methods, and the development of new sampling techniques. Further, advances are needed in priority intervention technologies and related factors, including thermal treatments, ionizing radiation treatments, ultra-violet radiation (UV) treatments, acidification, dehydration / water activity, disinfectant / biocides, temperature, freezing, and fermentation technologies.

Addressing agent characteristics, Jackson stated that it is not only important to determine the growth, survival, and resistance of certain pathogens but to examine the effect of food characteristics and processing conditions on the stability of biologically derived toxins and toxic chemicals.

Some needs in this area include: determining the effects of food composition parameters on the radiation doses needed to inactivate vegetative cells of microorganisms; characterizing the stability of biologically derived toxins and toxic chemicals during lactic acid fermentations of the type used to produce fermented dairy products; and establishing partition coefficient values needed to develop solvent extraction methods for the separation of various biologically derived toxins and toxic chemicals from foods. She also mentioned the lack of data on dose-response relationships for oral ingestion via foods in specific microorganisms using certain biologically derived toxins and toxic chemicals.

Jackson described the methodological challenges involved in sampling. Detection systems are going to smaller and smaller samples, while our need is the exact opposite. According to Jackson, detection research remains the number one priority in food defense. For example, how do you examine cargo coming across the border when you only have approximately 20 minutes? Not only do you need rapid detection, but also the right detection. You cannot assume homogeneous distribution in a production lot or even a single item, or that the contaminant is on the surface, or even that the contamination is geographically or temporally homogeneous. Effective terrorism does not require all items be contaminated. The way to solve this problem is to take more samples, limited by cost, to take larger samples, using new technologies, and to take smarter samples, using effective screening technologies based on better intelligence.

Finally, Jackson discussed the critical need for economic modeling and estimates for response and recovery from an intentional food contamination event. There is a critical need for a better understanding of the psychological and sociological response from the public to an intentional food contamination event and of the costs and benefits of preparedness and mitigation strategies. To do this, it is critical to understand the most effective places to apply countermeasures within the farm-to-table continuum. Dynamic models could assist in determining what technology needs to be developed or implemented, is cost-effective, and provides sufficient benefits to justify the expenditure. With the advancement of many technologies, collaboration among partners can help eliminate many of the challenges in food defense.

Mr. Robert Hooks, Deputy Assistant Secretary for WMD and BioDefense in the Department of Homeland Security's (DHS) Office of Health Affairs (OHA), spoke next. Hooks is responsible for the Department's early detection biodefense programs including Biowatch, the National Biosurveillance Integration Center, biological threat mitigation efforts, and homeland security programs in animal security and food defense. Hooks discussed how DHS collaborates with other departments, notably USDA and FDA. These departments are the "domain experts" in the food safety area, developing technologies that can meet the food safety, food security, food defense, and food protection needs of the country. The role of DHS is to look at the security implications across the nation, especially in catastrophic events, and the integrated impact to society, industry, and the nation's infrastructure. FDA and USDA identify, locate, prevent, and mitigate the impacts of a particular event, such as a pathogen contamination.

One major challenge, according to Hooks, is in the modeling and analysis area. Some questions DHS grapples with are: What models do we have in place to look from a national perspective if there were a major food contamination event, and how will it spread across the country? How will this event affect the population, critical infrastructures, and the economy? Finally, what mitigation measures can we put in place to reduce that impact? To answer these questions and to get ahead of the problem, DHS uses forward-looking cues based on information from FDA, other federal agencies, the private sector, and the open press. By clustering data from pathogen contamination outbreaks and overlaying it with transportation routes around the nation, DHS uses an integrated approach across the federal government to identify sources of contamination. It can then share that information with its partners at FDA.

DHS creates a layered approach to catastrophic events, Hooks explained. This requires technology, operations, policies, regulations, and partnerships between the federal, state, and local governments, the private sector, NGOs, and the international community. Within DHS, the OHA coordinates experts working on complementary activities. The Science and Technology Directorate focuses on bio-threat risk assessment, what agents or vectors of introduction could cause catastrophic food contamination events, and where those events can cause loss of human life, severe economic damage, or other societal consequences. The Infrastructure Protection Branch focuses on the food and agriculture sector through their coordinating council, which USDA and FDA co-lead. OHA has developed a *Food Shield* website, which provides a single collaborative environment with the private sector that provides the best lessons learned in food contamination/food protection at the state and local level. This helps insure that, during an ongoing event, the best information is available on both the preparedness side, and the response and recovery side. Working with FEMA, OHA determines how best to apply grant funding. To which states and in what areas of food and agriculture should funding be awarded? Using benchmarking tools that create a systematic approach to identify readiness capability allows for the most effective use of grant funding.

Hooks emphasized that DHS sees the current environment as one in which there are communities in partnership, all of which have different strengths to bring to bear, so that the nation can be protected.

INDUSTRY PERSPECTIVES

Dr. Catherine Woteki, Director of Food Safety at Mars Inc., provided the perspective of the global food industry. Woteki posed four questions:

- Who is responsible for food safety?
- What does that mean for research?

- What are the current challenges?
- Do we need new models for food safety research?

Industry is responsible for the safety of its products, while the government's role is to (1) set standards, (2) verify that industry is meeting their standards, and (3) enforce the standards when necessary. US government food safety decisions—pre-market approval standards and regulations on naturally occurring hazards, environmental contaminants, and economic adulterants—are inherently science-based. Risk assessment assists the agencies in determining an appropriate risk management response, while risk communication informs participants throughout the process.

Both industry and government—those who produce food and those who regulate food—share responsibility for food safety and, hence, food safety research. Areas for government research include monitoring/surveillance/inspection of food supply, monitoring/surveillance/outbreak investigation of human illnesses, risk assessment, fundamental research, and studying foodborne disease processes, treatments, and mitigation strategies. Industry research includes food engineering research, pre-market safety studies, addressing priorities specific to products, processing methods, and HACCP validation, and studying pre-competitive, commonly shared problems. Industry studies many commonly shared problems that companies tend to fund through their trade associations or through organizations like the International Life Sciences Institute.

Woteki broke down the food safety budget by area, including surveillance, inspection, risk assessment, research, and education. She noted that it is unknown how much money is spent on food safety in the industry. These are areas where estimates need to be updated, so that participants are aware of what resources might be lacking.

She then posed several current challenges from research, funding, and public perception perspectives, the first three being challenges the industry has seen for the last decade. The first challenge is the breadth of the hazards with respect to the prevention, detection, mitigation, control, and elimination during processing, post-processing, distribution, and preparation throughout the food supply chain. The second challenge is the enormous scope of the food system, which includes fresh fruits and vegetables, meat, poultry, fish, egg, dairy products, processed foods, and imported foods. Not only do different matrices pose analytical challenges, but different countries of origin pose differing hazards. The third challenge is that there is no common research agenda, either as a nationally coordinated research agenda or as the integration of research efforts among agencies. Current funding is inadequate to support a science-based system, and the national laboratories have not been engaged.

Challenge number four, from the food industry perspective, is prevention technologies. As raw materials come into our plants, the best technologies need to be in place to identify chemical contaminants and pathogens. Research talent and capacity exists, certainly in our national laboratories, as well as in our universities. They respond whenever there is a problem, but there has not been a concerted effort on the part of the food industry to fund the long term research needed to develop prevention technologies. The national labs may well have technologies and insights from other applications that can be put in place for food safety.

The fourth challenge, Woteki explained, which is an emerging one, has to do with a public mistrust of industry-supported research. For the food industry and for regulatory agencies now and moving forward, the question of who funds the research to demonstrate safety is going to be increasingly problematic. As we move forward in research, she urged that we bring the public along in an understanding of our joint responsibilities and the importance of industry funding of research to address these questions.

It is time for new models for food safety research, Woteki concluded. There needs to be a common research agenda focusing on a small number of high priority issues shared by regulatory agencies, research agencies, including national laboratories, companies, and NGOs, as well as new funding approaches to engage universities, intramural government laboratories, and industry scientists.

Dr. Robert F. Standaert of Oak Ridge National Laboratory (ORNL) and **Mr. John Hammerstone** of Mars, Inc. described a pilot partnership between a company and a national laboratory, in order to stimulate discussion about how more of these could be more formalized and what is possible at the national laboratory-industry interface. They presented the Black Swan Theory to explain the existence and occurrence of high-impact, hard-to-predict, and rare events that are beyond the realm of normal expectations in the food industry. The problem with the "black swan" is that it can come in many forms, such as Salmonella, dioxin, a combination of melamine and cyanuric acid, or even "mineral oil" or a mis-formulated vitamin mix. After Mars collaborated with Pacific Northwest National Laboratory (PNNL) to help identify the melamine contamination in one of their products, the company decided to pursue collaboration within the national laboratories in order to help prevent, or more rapidly respond to, future "black swan" events. A subsequent dialogue between Mars and ORNL yielded the possibility that the assets of the national laboratories could be usefully engaged for food safety and security.

Since their partnership is in the very early stages, Standaert and Hammerstone talked about the partnership from a structural perspective, and how to combine talents. First, there must be communication, which involves plant trips, multidisciplinary conferences, and embedding staff. This involves having food safety and manufacturing people interact with national lab scientists via workshops and presentations. There must be a presence on the ground so that individuals from these two cultures can work side by side and get an understanding of the needs, priorities, and goals of the projects.

According to Standaert and Hammerstone, to solve food safety challenges there has to be additional funding sources, a consortium of the industry or other government funding. This can enable effective partnership with the national labs. Also, it is important to have industry people who know the national labs, their exceptional talent pool, their large "tool box," and their knowledge contact points. Partnering with the national laboratories is not about satisfying scientific curiosities. It is about developing a technology or robust instrument and integrating it into a supply chain or core factory.

Standaert and Hammerstone concluded their talk by going over some of the projects they are collaborating on. One involves building a stand-off laser using new infrared laser technology that is tunable, to get a mid-IR spectrum. This technology, developed for the military, will allow better detection of bacteria. The next project involves desorption mass spectroscopy technology, which uses a very mild surface desorption technique to continuously scan across the manufacturing supply chain in order to continuously sample and extrapolate it in a very inexpensive way. The last project involves developing a chemical-biological mass spectrometer (CBMS), again taken from military use, in order to constantly "sniff" the environment within manufacturing facilities. Mars, Inc. is excited about these new technologies because they have already been translated to hostile environments and can be used effectively to address the issue of food safety.

KEYNOTE ADDRESS: FDA'S FOODS PROGRAM

Keynote speaker **Dr. Stephen Sundlof**, Director of the Center for Food Safety and Applied Nutrition with the U.S. Food and Drug Administration, discussed "Reshaping FDA's Foods Program". President Obama's Food Safety Working Group brought together cabinet secretaries and senior officials of many agencies to advise the President on how we can upgrade our food safety laws for the 21st century, foster coordination throughout government, and ensure that we are not just designing laws that will keep the American people safe, but enforcing them. The impetus for the working group was a year of several outbreaks that brought food safety to the public's attention. The working group has met on numerous occasions and is currently drafting a final report.

Listening to many interested parties, the working group addressed five key areas—prevention, strengthening surveillance and risk analysis, expanding risk-based inspection and enforcement, rapidly responding to outbreaks to facilitate recovery, and how to identify the resources available to make all these things happen. Discussions involved three core food safety principles:

1. Preventing harm to consumers is the first priority.
2. Effective food safety inspections and enforcement depend upon good data and analysis.
3. Outbreaks of foodborne illness should be identified quickly and stopped.

Out of these discussions came key recommendations for FDA:

- Preventing Salmonella in Eggs
- Preventing E. coli 0157:H7 Contamination of Leafy Greens, Melons, and Tomatoes
- Developing Industry Product Tracing Systems
- Clarifying Responsibilities and Improving Accountability
- Modernizing Statutes

President Obama's 2010 budget contains over a billion dollars for the Food and Drug Administration safety efforts to increase the improve inspections, domestic surveillance, laboratory capacity and domestic response to prevent and control foodborne illnesses. Much of the cost drivers will be on inspection, with emphasis on increased inspection frequencies. The FDA is undergoing a major paradigm shift away from mitigating harm by removing unsafe products from the market to preventing harm by keeping unsafe food from entering commerce in the first place. This involves establishing a reportable food registry. Sundlof explained that a reportable food is any article of food (other than infant formula) for which there is a reasonable probability that its use, or exposure to it, will cause serious adverse health consequences or death to humans or animals. This requirement should have a major impact on being able to identify more quickly where problems may occur.

FDA's new authorities, under bills that are currently making their way through Congress, include preventive controls, performance standards, risk-based inspection schedules, records access, product tracing, administrative detention, mandatory recall authority, and importer controls. FDA's foods program is also working to improve partnerships within the U.S. and abroad, which not only means strengthening alliances with federal partners, such as CDC and USDA, but seeking better cooperation from FDA's international counterparts. FDA is working to create an integrated national food safety system, which will help the food industry produce and market safe food.

According to Sundlof, this is a historic time for re-shaping FDA's Foods Program. As FDA moves forward, it will seek the partnership and support of stakeholders to bring about meaningful change. Success will depend on a team effort and partnerships. There will also be about a ten percent increase in the FDA budget for food safety research, related to rapid analysis development, nutrition, and consumer research.

BREAKOUT SESSION I: EXISTING TECHNOLOGIES IN THE NATIONAL LABORATORIES

The first breakout session was designed to share what technologies already exist in the national laboratory network that could be applied to the problems defined in the morning session.

The first group identified key technologies that are readily available from Los Alamos, Savannah River, Idaho, Lawrence Berkeley, and Lawrence Livermore national laboratories. At Los Alamos, e.g., sequencing technology could be used in rapid detection of pathogens. They have also done epidemiological modeling, looking at receptor differentiation between humans and other animals and how that might be affected if an outbreak occurred. Savannah River identified sample collection, from aerosols to water to complex matrices, as an area where they have done a lot of work. Idaho has done work with regional pathogens and the development of rapid polymerase chain reaction detection/DNA detection assays. They have worked quite a bit with *brucella*, which is a problem in that area of the country, and with *Coxiella burnetii*.

Lawrence Berkley has done a lot of work with microbial detection and microarray development using ribosomal markers. While this involves work with the human biome, they have developed a phylogeny chip and have a matrix-based system to look at rapid detection of different organisms that could be translated to the food safety arena. They are developing a microchip-based array to detect fungi. Lawrence Livermore has worked extensively on bioinformatics, which can be of great use to the food safety area. They have also developed rapid multiplex PCR assays for many different disease groups, including avian influenza, foot and mouth disease, and rule-out panels for bovine. They also have done work for commercial concerns to develop these capabilities. They have developed microarrays with the capability to pick up any unknown, for antibiotic resistance, for essentially any unknown microorganism, and for the detection of virulence factors.

The second group identified key technologies that are readily available from Oak Ridge, Pacific Northwest, Argonne, and Sandia national laboratories. Oak Ridge discussed standoff laser detection, using it to detect *Salmonella* in food in real time. Pacific Northwest also uses standoff laser detection technology methods that are for explosives but that can also be tailored to any other chemical adulterant, versus a biological adulterant. They also have done extensive work on auto sample preparation platforms with nucleic acid analysis, which gives a very low detection limit. That technology is being funded by the Northwest Food Processors Association, for use with *listeria* detection technologies. Pacific Northwest also has communication and expectation modulation with regard to how quickly a tool can be developed and deployed. Additionally, they have worked on microarrays with toxin detection. Microarrays are very popular because of the potential to detect many things simultaneously.

Argonne has worked on high throughput proteomic work with biomarker detection and the development of bio reactors for molecular signatures, specifically developing a library of signatures and patterns that could be fed into other detection methodologies. Sandia has done work in micro-fluidics and miniaturizing and automating lab scale implementation. This small scale robust bedside tool can be used for very small samples. This technology has been used for nutritional analysis, for example.

The final group of participants identified technologies in five distinct areas: forensic technologies in chemical and microbiotics, detection technologies, standoff laser technology, mass spectrometry point, and other analytic technologies. They discussed simulation and agent based modeling, informatics and prediction, human factors technologies, such as models of Tourette's risk analysis and processes focusing on preventive measurements, vulnerability analysis, biological technologies, and materials science. For example, Oak Ridge is working on creating surfaces that prevent contaminations being spread by keeping surfaces clean. This group also discussed how to decide which problems to follow and which have the greatest potential impact for providing food safety, probability of recurrence, cost to scale/implementation, and production challenges.

UNIVERSITY RESEARCH IN FOOD SAFETY AND FOOD DEFENSE

Dr. Shaun Kennedy, Director of the National Center for Food Protection and Defense and Assistant Professor of Veterinary Population Medicine at University of Minnesota, presented the university perspective on the global complexity of the supply chain, and food safety research in the academic environment. Kennedy explained that food security technically means supply sufficiency, or access to nutritionally adequate and safe food. Food safety means system reliability, or reducing exposure to natural hazards, errors, and failures. Food defense means system resiliency, or reducing the impact of system attacks. And finally, food protection refers to the global food supply system safety and defense “umbrella.”

Kennedy used the example of a cheeseburger to highlight the complexity of the global supply chain. Every one of a cheeseburger’s ingredients has its own supply chain, and every one of those supply chains can become compromised, either through problems with food safety or food defense. In fact, 48,000 potential contamination scenarios are possible; not all of them are realistic, but most of them could be. If we then talk about deploying detection systems to deal with food safety or food defense, where do we test the system? And how many times do we test it? This, in combination with the fact that many of the ingredients are from global sources, is quite a daunting challenge.

The university environment, according to Kennedy, differs from the national laboratory environment in many ways. First, an investigator initiates studies in response to a sponsor’s area of interest, and the traditional model of lone investigators is giving way often to teams of investigators. Borders are becoming less relevant as a restriction to research, and the breadth of disciplines needed when studying food protection and defense is much broader than simply “food safety”.

Funding at the university level for food safety research comes from the federal government and from the private sector. The most common mechanism is to coordinate within/across campuses for access to faculty and funding, which includes research that is private sector fee-based, state funded, grant funded (federal agencies, foundations), based on agency contracts, or university supported. Within this framework, the functional food safety centers serve as a logical touch point for working with the national laboratories.

Kennedy then highlighted the various university centers that focus on different aspects of food safety, protection, and defense, before discussing the National Center for Food Protection and Defense (NCFPD), a Homeland Security Center of Excellence. NCFPD's mission is to reduce the likelihood of an attack, improve the nation's ability to respond effectively, and reduce the consequences of an attack. NCFPD carries out the mission of reducing the potential for catastrophic food system events by rendering targets unattractive, rapidly and accurately detecting attacks, responding effectively to minimize consequences, rapidly delivering effective recovery efforts, training/educating new scientists and professionals, and partnering and collaborating to ensure success. This occurs not only through broad academic collaboration, but through collaboration with diverse industries and associations, as well as federal, state, and local agencies.

NCFPD is structured by having research teams, each tackling one area. The first studies agents. It has the stated goals of: (1) fundamentally understanding the chemical, physical and biological attributes of "agents" that may be intentionally introduced into the food supply, (2) developing specialized biosensors that can expediently extract, concentrate, and detect such agents in foods and beverages, and (3) developing agent-specific strategies to prevent or recover from an intentional incident involving the food supply chain. Some examples of projects NCFPD is currently studying with respect to agents include: extraction and concentration of chemical and biological (ricin) toxins, and *Botulinum* neurotoxin sensing in food matrices.

The second team conducts event modeling research, with these goals: (1) to use event models for consequence, risk and vulnerability assessment, (2) to evaluate preparedness, response and recovery strategies, (3) to aid in decision support, and (4) to insure that emerging event models can communicate with one another, if required. An example of a project in this area is the vulnerability assessment and reduction of economic impact for the fruit and vegetable industry. This is a food defense assessment survey for fruit and vegetable shippers/growers, including threat point analysis to evaluate gaps. From this survey, NCFPD can develop intelligent/risk-based sampling procedures and dynamic market equilibrium models to simulate potential economic estimates of terrorist attacks. From these models, NCFPD develops training materials for the imported produce industry.

The third team, Kennedy outlined, studies system strategies research, with a focus on the following: (1) food supply chain designs that degrade gracefully and recover quickly when subjected to a major disruption (resiliency), (2) approaches to diagnose or predict the causes of major supply chain disruptions that are closely linked to the design of resilient food supply chains, (3) consumer confidence in the U.S. supply chain, and (4) the economic impact of a catastrophic terrorist food system attack. An example of a project in this area includes continuous tracking and analyzing consumer confidence in the U.S. food supply chain. This involves conducting trend/event analysis related to food defense and supply chain safety/security events, including concern with food defense relative to other terrorist targets. This allows NCFPD to predict how communications affect consumer attitudes and plans for food purchases and to construct a food system Consumer Confidence Index that estimates the effects of media coverage of adverse food safety/security events.

The fourth team conducts risk communication research, specifically on: (1) best practices for risk communication in potentially catastrophic events, and (2) approaches for engaging the media, across media types and audiences, as a resource for managing high risk and crisis events. A risk communication project example includes assessing message effectiveness with diverse cultural groups, based on learning styles. Each of these teams, Kennedy concluded, contributes to NCFPD's mission of defending the safety of the food system through research and education.

BREAKOUT SESSION II: RESEARCH PROGRAMS IN THE NATIONAL LABORATORIES

The second breakout session was designed to address what research programs exist in the national labs network that could be structured to address problems that have been discussed during this workshop.

The first group identified a number of technologies that come out of research programs at the national laboratories, including biological aspects of renewable energy, open source computational capabilities, leadership, supercomputing, materials science, grid security, and network transmission at the electrical network and the national infrastructure level. Several members of this group noted that these technologies have capabilities which could be applied to large supply chain networks of food and the logistics aspects of traceability. Infrastructure protection, for example, involves looking at the consequences of events and modeling vulnerability, say, in reactor safety. This is something that occurs a lot in reliability analysis, but uses methodologies, fault tree analysis, and various traditional reliability analyses that could be applied to food safety. Similarly, fault tree programs look at the estimated probabilities of all the possible things that could go wrong.

Other group members suggested that the energy science and engineering program at some labs has modeling and simulation capability on a systems level that could be applied to food safety. Another interesting program includes the analytics and large scale visualization, where very large amounts of data are taken and visualization technologies developed to analyze and create intuitions based on the data.

The next breakout group focused on propagation of effects and ancillary effects, i.e., those sectors affected by a take-down of the food safety environment. For example, how is the transportation sector affected because the food industry has halted? This group also discussed decontamination and restoration efforts. Currently efforts from Sandia are aimed at aircraft decontamination. Also, GIS data, bioinformatics, and visualization analytics can certainly be used in the food safety arena. Signature science can be tapped for food safety, some participants said, where markers are identified using proteomics data and comparing this with virulence markers. Modeling how humans interact with systems can help predict how humans will interact with their environment and information as they are given it. This program, called techno social predictive analytics, is currently an internal program at a national laboratory. The group discussed situational awareness and integrating policy responses and the possibility of using simulation and role playing games to help predict how people will react. Some thought that modeling supply chains and social and behavioral modeling might also be valuable.

The next group discussed new methods of decontamination of surfaces, equipment and factories, and tracking and tagging of food products, in order to trace them back to their source. Modeling could then be used to predict contamination.

The final group discussed how genomics and proteomics capabilities (microarrays) could integrate with NMR and nanotechnology to lead to some very precise fingerprinting. At Livermore, interagency modeling and atmospheric assessment predicts how hazardous agents might wind up in the atmosphere. This could potentially be applied to food safety to determine when/where certain hazardous agents could enter the supply chain. The group then discussed large scale data integration and modeling to address the global complexity of the food supply chain.

WRAP-UP

The workshop concluded with an open discussion about specific threats, from a food industry perspective, that can allow participants to start thinking hypothetically about what a project or program requirement might look like in a national laboratory that would leverage laboratory expertise and capability. The focus was on models of collaboration with the national laboratories through real-world examples from the food industry.

Specific examples included food contamination of the food supply chain (the unintentional), bio-terrorism of the supply chain (the intentional), and specific technological needs in the food industry, such as rapid detection. Some participants pointed out that, in an environment where consumers expect fresh food, rapid detection, or shortening the total time to result, becomes important in getting food out of the factory. Defining normal was important, they said, so they would know an aberration from normal. Indeed, in an industry where variability is certain, understanding normal was vital. Evaluating variants on certain decisions, policies and systems would allow industry to use models to help understand the functional variability and how it impacts risk. It makes good sense, several participants suggested, to pursue capabilities of modeling, sampling, and detection in food that are both practical and affordable.

ABOUT GUIRR

MISSION

GUIRR's formal mission, revised in 1995, is "to convene senior-most representatives from government, universities, and industry to define and explore critical issues related to the national and global science and technology agenda that are of shared interest; to frame the next critical question stemming from current debate and analysis; and to incubate activities of on-going value to the stakeholders. This forum will be designed to facilitate candid dialogue among participants, to foster self-implementing activities, and, where appropriate, to carry awareness of consequences to the wider public."

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