By Chris Thompson and Fred Payne, Ph.D.

A Real-life Food Defense Challenge: Bulk Milk Transportation

Conversations regarding food defense often intermingle with the closely related topics of food safety and traceability. This is primarily because food industry professionals tend to think of these issues in a very broad sense under the comprehensive umbrella of food protection.

Most decision makers within any food industry organization understand the importance of food protection, yet

these individuals are also wary of incurring new operational expenses and implementing major changes in their organization's operational processes. Plus, food safety professionals and business-minded decision makers may not always communicate effectively. It is important for everyone in the food supply chain to recognize that all levels of an organization can derive benefit from the collection, documentation, maintenance and application of traceability data. The key to gaining buy-in from decision makers is to speak their language. We need a considerable amount of data to ensure food safety, food defense and traceability, but that data can also be used to improve operational efficiencies and reduce overall costs.

Achieving consensus on the value of gathering data is a good first step, but there may be many operational hurdles along the way. It is essential to bridge theoretical solutions with practical applications that take into account the day-to-day realities of conventional operations within our nation's existing food production and distribution system.

An Initial Look at BMT

The dairy industry presents unique challenges to food protection, particularly in the area of bulk milk transportation (BMT). First, the availability of a raw milk supply within a given geographic area is dynamic for biological reasons. In the spring when weather conditions are favorable for the dairy cow, milk production increases significantly. In the summer when conditions are not favorable, production drops. To further complicate matters, the demand for milk fluctuates due to seasonal factors and contractual obligations with school systems and other institu-

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tions. Regional differences also exist as. Farms in the East and Midwest tend to be smaller than farms in the western U.S. Combined with a perishable food product that must be regularly shipped off the farm, transported according to prescribed procedures and processed within a quick time frame, it becomes apparent that BMT presents distinctive challenges not experienced by most segments of the food industry.

The modern BMT system involves a number of interrelated dairy industry sub-segments that share responsibilities regarding the defense and safety of the transportation network. These sub-segments include producers, milk marketing agencies, dairy processors and milk transportation companies. Typically, milk marketing agencies procure milk from dairy farmers and organize the supply of bulk milk to dairy processors. Dairy processors reach agreements with milk marketing agencies regarding supply volumes, quality, delivery times and other logistical factors. Milk transportation companies may operate independently or through contractual agreements with milk marketing agencies, processors, producers or, in some cases, through a combination of contracts with each of these groups. Information about food security and safety is shared simultaneously among all groups.

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Collectively, milk transportation requires a substantial amount of excess transit capital, primarily in the form of food-grade tankers. Extra tankers are required to accommodate fluctuations in milk production, transportation schedules and normal glitches that can occur in transportation systems. Certainly, there are times during the year when tankers will be used to transport other food-grade products. This introduces additional complications as other food-grade products have unique requirements related to washing and sanitizing, how products are transported and the required documentation associated with their conveyance. Managing all this equipment and ensuring proper procedures and cargo compatibility–all while guaranteeing that milk is picked up at the farm and delivered to the dairy processor each day–can become an overwhelming task.

An Opportunity for the Dairy Industry

The challenges inherent in BMT relating to the development of a comprehensive food defense strategy presented an opportunity to develop a model traceability system that would also be applicable to other sectors of the food industry. In late 2005, funding from the U.S. Department of Homeland Security (DHS) and the National Institute for Hometown Security (NIHS) made possible the development of a prototype bulk milk transport security system that would secure the cargo and collect all milk transport data from the dairy farm to the processor. Other objectives of this project included allowing only authorized personnel to have access to the tanker, monitoring of the milk and tanker continuously during transportation, and providing this information in a usable format to the dairy industry.

Why would the DHS be interested in BMT? The DHS is generally interested in how all bulk food products are assembled, stored and transported, but bulk milk exhibits characteristics that give rise to particular concern. First, even on small farms, milk is produced in rather large batch sizes. Then, as milk supplies are assembled and delivered to processors, they are further commingled during transport/storage and thoroughly mixed during processing. Once processed, dairy products are then quickly distributed to retail locations, where product turnover occurs rapidly. In short, we take milk from the cow to the consumer very quickly. Consequently, all aspects of food protection (in this case, milk) are important to any agency responsible for citizenry protection.

The NIHS is a private, nonprofit organization that aligns projects and research objectives with the needs of the DHS. The NIHS works with Kentucky universities by funding the development of technologies to protect rural America's critical infrastructure. The institute encourages cooperation among Kentucky universities and collaboration with industry stakeholder groups. The funded project was led by researchers at the University of Kentucky College of Agriculture (Lexington) and involved researchers from Western Kentucky University (Bowling Green) and the University of Louisville (Louisville). A description of the ongoing project follows.

Developing a BMT Security System

The research and development team planned to incorporate existing technologies into a BMT security solution. The first strategy was to ask the dairy industry what it wanted in a transportation security system. An advisory team, comprised of stakeholders who would be directly impacted by any security system deployed within milk transportation, was assembled. Representatives from dairy processors, milk marketing agencies, milk transportation companies, tanker manufacturers/distributors and dairy regulatory agencies were included. This was a pragmatic, operations-oriented group of collaborators interested in practical solutions that would not disrupt normal operations. Additionally, some stakeholders had competing interests and legitimate concerns about how any security system might impact their specific operation.

The BMT industry currently utilizes well-established food safety, food defense and operational procedures. However, these protocols are labor- and paperwork-intensive and are subject to the challenges of legibility, interpretation and accuracy. Transporters hand-record information on load manifests, dairy farm milk pickup receipts and official milk samples obtained on the farm route. Additionally, they

keep records associated with the industry's tanker seal accountability program. Finally, transport tankers are also accompanied by a wash and sanitization document. All of these tasks and record-keeping activities are usually performed under less than ideal working conditions. When the load of milk arrives at the processor, documents, seals, etc. are evaluated and any discrepancy results in further investigation. When this occurs, in the best case, the investigation will result in a delay; in the worst case, a load of milk may need to be discarded. Neither situation is desirable. The dairy industry stakeholders agreed that while these current transportation protocols have been effective, many benefits could be realized from automating and improving these processes.

In addition, it became apparent during the planning phase that a comprehensive system for BMT would need to include an added component of security. Here it is important to distinguish between security and accountability. Security requires limiting access to a vessel–in our case, a milk tanker. Accountability systems, such as utilization of numbered seals, do not provide true security as seals can be easily broken. Nevertheless, accountability seals, along with their accompanying records, are important because they provide us with documentation as to how often our vessel has been accessed. Unfortunately, accountability systems are susceptible to "spoofing" because they rely on people to interpret records. Ideally, an enhanced system would incorporate both security and accountability concepts into a food defense surveillance system for BMT.

Since the food safety and defense protocols for BMT are shared among milk transportation companies, marketing agencies and processors, the defense system would need to offer flexibility for each of these users and not interfere with commerce. To achieve this goal, the system would need to provide the dairy industry with all relevant information about milk transportation processes:

- Who has had access to the tanker and its contents?
- Why did access occur?
- Where did access occur?
- What time did the access event occur?
- What else was going on with the tanker (e.g., what was the milk temperature)?

All of this would need to be accomplished in a reasonably cost-effective manner. To realize these goals, a tremendous volume of timely information is required and this information must be provided in a format meaningful to the industry to enable buy-in from upper management.

Building the BMT Security System

Keeping cost and standardization of information in mind, we determined that the security system's foundation would be a robust, secure data server. Users access the server via the Internet and enter relevant information. Some information entered into the server is proprietary; therefore, this information is partitioned so that each user group only has access to its own information. The only information common to all the users is information currently shared in the milk transportation industry's paperwork-driven system.

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To gather data on the milk route, a small handheld computer was selected. The primary user is the milk truck operator, but other users might include milk marketing agency officials, plant employees or inspectors. The handheld device utilizes a bar code reader and cell phone, as well as Wi-Fi and Bluetooth® wireless communication applications. Exclusive bar codes identify objects and people encountered during routine milk transportation activities. Objects include tractors, tanker trailers, farm bulk milk tanks and milk sample vials. Individuals typically have bar codes on employee identification badges or official documents. Truck operators are also provided a printer used to print label documents. The printed labels are used on official milk sample vials obtained at each dairy farm and as a component of the dairy farmer's milk pickup record. Locations are identified with global positioning system (GPS) coordinates.

The final feature of the system is the tank monitoring system (TMS). The TMS consists of a computer processor physically mounted on the tanker. The processor is wired to electronic locks on tanker ports, a user interface (keypad and screen), temperature sensors, a GPS receiver, a Wi-Fi antenna, a cell phone and an auxiliary battery to power the TMS when it is not connected to a vehicle power source.

The handheld and server update each other via cell phone. The TMS constantly monitors any relevant changes on the tanker, and as long as the handheld is within the tanker's vicinity, the TMS will update the handheld via Wi-Fi. If the handheld is not in the vicinity of the tanker, the communication is cell phone-based.

While many of the comprehensive system's building blocks have been adapted from other uses, it is important to recognize that the TMS computer processor was specifically designed to collect and process data relevant to bulk food transportation operations and security. Additionally, the software functionality for each processor–data server, handheld and TMS–was designed specifically for the dairy industry's needs. These needs include providing flexibility for using the system for other bulk food-grade products. Input regarding software development is where the advisory team's attention to detail paid dividends and ensured a functional, user-friendly system.

A Day in the Life of the BMT Security System

The milk truck operator logs into the system with the handheld by scanning an em-

ployee ID bar code followed by entry of a user authorization code. This process is randomly repeated throughout the day for identity verification. After the operator scans the tractor and tanker trailer, the handheld receives updates from the server via cell phone. The operator is informed of critical information regarding the tanker trailer and milk routes (i.e., proper washing and sanitization of the tanker, etc.).

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Upon arrival at a farm, the operator requests to open the lock on the rear of the truck using either the handheld or the user interface on the TMS. A "reason code" for opening the rear door is required. An example of a reason code for unlocking is "to load milk." This is an essential piece of information for security purposes. After this information is communicated to the server, an evaluation can be made to ascertain if this "reason code" is appropriate for the GPS coordinate received from this location. When the rear door of the tanker is unlocked, the action is time- and date-stamped. The operator proceeds to the farm's milk house and scans the farm tank bar code, and the required information auto-populates on the handheld screen. After appropriate farm pickup information is entered into the handheld, sample labels and the dairy producer's farm pickup records are printed with all relevant information. The milk is then pumped into the tanker and the rear door is locked.

Multiple recordable events have occurred during this short time span. The door on the tanker was opened and closed, the temperature of the tanker has gone from air temperature to cold milk temperature, plus the farm pickup information has been assembled on the handheld. At this point, information is communicated across the system. The handheld, TMS and data server synchronize and share relevant data, resulting in redundant storage of information critical to the BMT industry. If cell service is not available at this particular location, redundancy is accomplished by storing the data on both the handheld and TMS.

Updates are repeated throughout the day as the operator continues along the route. During transport, if a specified standard exceeds established tolerances, the operator is alerted and can follow established procedures to handle the alert.

When the load of milk arrives at the plant, procedures similar to those used on the farm are followed. Bar codes are scanned, load approval information is entered into the handheld and the unlocking and locking of the tanker is documented. Additionally, wash and sanitization processes performed on the tanker after the milk has been unloaded are documented via temperature sensors and the TMS. After all procedures at the plant are performed, the truck driver and plant employee sign a signature box on the handheld and the final "load information" is uploaded to the server. At this point, appropriate individuals can access the load information on the server via the internet to print documents, run reports or download data.

Recent Updates and Future Efforts

The integrated BMT system was demonstrated nationally in the fall of 2008 with positive feedback. One concern identified was the difficulty in deploying such a comprehensive system on a large-scale basis. With that in mind, the research and development team has partitioned the system into modules to facili-

Guiding Principles for Development of the BMT Security System

1) Operate within current milk transport infrastructure
   - This guided the technology selection for the system, ease of deployment and technological costs were primary considerations.
2) Keep the information with the milk
   - Tankers are regularly moved with multiple tractors; the milk and security information must remain with the tanker trailer.
3) Provide redundant data storage
   - Information must be stored in multiple locations in case one component of the system malfunctions. Data is stored on the handheld, server and TMS.
   - Storage must comply with industry requirements. People often speak of "going paperless" with new technological systems. However, the dairy industry requires printed documentation at certain intervals. Required documentation is generated as needed with the system.
4) Ensure security and accountability
   - Access to the tanker is limited to authorized personnel only. If an authorized person does access the tanker, the system identifies who, when, where and why this access occurred.
5) Allow flexibility and adaptability
   - Milk transport processes vary across regions and organizations. The system was designed for maximum flexibility, including the ability to account for transporting other food-grade products.
6) Manage data gathering to ensure accuracy
   - Data integrity is essential for security and operational protocols. Parameters have been established for critical data associated with milk transportation processes. If data outside those parameters are entered, the operator is alerted to minimize errors. After data is uploaded to the server, it can be analyzed and exception reports can be generated if industry parameters are out of tolerance.

tate an initial deployment of only the handheld and server-side components of the system. The TMS module could then be easily integrated into the transportation security system as tankers are retrofitted with the components. In 2009, both the handheld/server-only system and an optimized comprehensive system were successfully field-tested.

Future developments are primarily related to software enhancements. While there are specific processes required for BMT activities everywhere, there will always be customized protocols and information needs among geographic regions and commercial enterprises. For this project, the research and development team focused on ensuring that the tanker is only accessible to authorized persons, that critical activities associated with the tanker are continually monitored and that relevant milk transportation data is collected. With these goals achieved, the types of operational reports, security analyses or traceability queries requested of the data are limitless.

The Bottom Line

The benefits of the milk transport security system are two-fold: enhanced security and improved information management. The security aspects of the system have been designed to address both enterprise risks and operational risks. While security was the primary objective of this project, it must be recognized that the complete integration of all milk transport activities provides a significant value for the dairy industry.

Overall, each industry sub-segment should realize considerable cost savings by implementing the security system, most directly from process-error reductions and improved efficiencies, which result in lower capital and labor expenditures.

It is important to note that the cost savings described above are not theoretical. As part of the project, the research and development team painstakingly quantified the benefits and cost savings associated with the system and had these estimates confirmed by the dairy industry collaborators.

Simultaneously, the dairy industry will benefit from enhanced security and traceability that is not attainable under current transport protocols. These aspects of the BMT security system provide considerable economic incentive for forward-thinking decision makers concerned with limiting the scope of a disruption.

Regardless of whether enhanced food protection systems are required for food industries in the future, the milk transport security system developed in this project offers each dairy industry user considerable incentives for adoption. All food industry segments are interested in both collecting more data and being able to use this data to respond quickly to a crisis. Having specific data about supply chain operations and raw ingredients provides the ability to identify problems at their source and minimize the scope of problems we might encounter.

While people tend to think of food defense and traceability as costs, we can create considerable value if we can tie these concepts in with our other operational processes. This project has demonstrated that food defense systems, if thought out carefully with input from users, can be excellent tools for improving efficiencies and minimizing costs. ■

Conflict of Interest Disclosure

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To find out more about the milk transport security and traceability system, go to www.rs.uky.edu/milktransport.