The Transformational Food Manufacturing Initiative
Clean Energy Smart Manufacturing Innovation Institute

Final Report
National Workshop on Food Safety, Quality, and Traceability
August 1, 2018
Champions Center at General Mills World Headquarters
1 General Mills Blvd, Golden Valley, MN 55427

Workshop Summary

The workshop was productive in developing Food Safety and Traceability project ideas and identifying partnerships to develop proposals in response to upcoming CESMII project calls. A total of 11 abstracts were developed and ranked. Some of the abstracts described projects that were substantially the same, and those scores were aggregated in the rankings.

The highest priority indicated by the participants was around data standards and structures. Primary data requirements include food and ingredient quality metrics (as opposed to quantity metrics commonly used today. Implied in this topic is the ability to track the data across the supply chain (traceability) as well. This topic originated from the AI group which also has the most interest in forming a development team.

The next highest priority had to do with managing uncertainty in ingredients as well as the ability to dynamically manage production line configurations. Topics discussed included platform requirements, digital twining of production lines, and the integration of analytics to manage product quality in the face of variability of ingredient characteristics.

Recommendation

CESMII and the TFM community form two affinity groups to further refine the projects for proposal to CESMII funding opportunities:

- Data Standards for Food Safety and Traceability. The charter of this group is to determine and suggest standard data fields for ingredient quality and contaminant characteristics. This should be in coordination with existing industry activities already underway (e.g. Grocery Manufacturers Association – Smart Label Initiative)
- SM Platform Requirements and Implementations for Food Safety and Traceability. This group would examine the food manufacturing problem from the platform point of view and put in place plans for the development of platform components and products to create process digital twins and the associated analytics to manage product safety with follow-on applications for dynamic recipe management.

Final Report
CESMII/TFM National Workshop on Food Safety, Quality, and Traceability
August 1, 2018

Attendees: For the full list of attendees, please see Appendix A.

- Companies represented include: Cargill, Conagra Brands, CRB, General Mills, Grantek Systems Integration, Induction Food Systems, Johnson and Johnson, Neogen, Pulse Integration, Savigent, Siemens, Sneakz, ThinkIQ
- Institutions and Governmental Entities represented include: CESMII, NIST, Northwestern University, Rensselaer Polytechnic University, Texas A&M University, University of California Davis, University of California Irvine, University of Nebraska Lincoln, USDA-NIFA

Agenda: See Appendix B.

Format: The workshop was based on the Transformational Food Manufacturing (TFM) Report from June 8, 2018. From the report, four topical areas were selected for discussions and development. They were:

- Process Sensor Technologies for Food Safety and Security
- Artificial Intelligence and Virtual/Augmented Reality for Design and Analysis
- Advanced Process Technologies for Safety and Efficiency
- Packaging and Sensors for Consumer Awareness and Information

Each of these topics were examined by self-selected small groups and each group development one or more abstract topics for further considerations by groups developing CESMII Road Map requirements and/or proposals in response to CESMII funding opportunities

Following the break-out sessions, a prioritization session was held where each workshop attendee scored the abstracts. Each attendee was able to score each abstract for priority: High, Medium, and Low. The abstract titles and scores are shown in tabular form in the results section of this report. The results of scoring will be forwarded to CESMII for input into its road mapping process and formation of groups to examine the topic and develop project plans from the highest scoring abstracts.

A post workshop survey was also distributed. Results of the survey is included in the results section.

Results: Each of the four topical areas were explored and developed abstracts/topics that addressed the topical area.

Topical Area 1: Process Sensor Technologies for Food Safety and Security

The Process Sensor discussions for food safety focused on real-time sensing and the associated data and analytics required, for food safety and security. Discussions included both contaminant sensors and sensors for validation of ingredients. Several sub-groups developed abstracts around this topic.

Abstract 1a. Sensor to detect contaminants (and eventually other stuff) – Briefed by Scott Sandler

Develop the ability to detect the top 4 contaminants (minimally) and integrate the data into a complete digital thread of a pilot industrial process (batch and or continuous). So that we have eliminated any food production being released to the consumer with these contaminants present.

While this solution specifically targets food manufactures, the general strategy could be applied across the whole food supply chain and even to other manufacturing segments such as Pharma.

The project is expected to run 18 to 24 months with regular milestones.

Abstract 1b. Pathogenic Detection for Food Safety – Briefed by Wayne Daley

Pathogens are significant food safety risk to consumers and contribute to food waste and cost to producers financially and reputation. Methods are needed to monitor and detect pathogens throughout the food manufacturing environment both process and raw materials,

Proposals to develop strategic partnerships along with the necessary analytics and process modeling for the delivery of methods and tools that ensure the preventative, detection and elimination of pathogens in food products. Expectations for the next 5 – 10 years

- Micro sensors
- Optical scanners
- Bio-sensor
- Nano-sensors

Analytics and process modeling complemented with real time analytics and process modeling for more effective process sanitation that was accessible scalable, affordable, robust that can survive the production environment.

Expected results

- Reduction in frequency of sanitation events
- Elimination of recalls driven by pathogens
- Stakeholder visibility and assurance enhancing brand equity and value
- Reduction of waste

Table 1. Process Sensor Technology Abstract Scoring

Abstract	Title	H	M	L
1a	Sensors to detect contaminants	5	6	2
1b	Pathogenic Detection for Food Safety	4	4	3

Topical Area 2: Artificial Intelligence and Virtual/Augmented Reality for Design and Analysis

This group centered on the opportunities that Artificial Intelligence (AI) or other analytic technologies and augmented/virtual reality (A/VR) could present for food safety and traceability through advanced design and analysis. Advances in AI could identify emerging food safety threats through data analysis and A/VR presents opportunities to increase human situational awareness to be able to timely act upon these indications.

Abstract 2a. Cloud-Based Data Structure – Briefed by Jill Brigham

Develop a cloud-based data framework structure enabling food safety, transparency and efficiencies by establishing a digital thread for the entire food supply chain. Enables methods for processing disparate data. System provides a right to use/right to know upload/download capability for data transfer.

See also Grocery Manufacturers Association – Smart Label Initiative

Abstract 2b. Data Flow at the Shop Level – Briefed by Richard King

Pilot Project: Shop Floor Level – right information – right time – right vehicle

Determine the pertinent information directly upstream and downstream at the correct time with AR to the operators running the line

Information

- Production: OGE, output
- Safety: PGAs, PAV
- Machine downtime: visual, maintenance
- Schedule: completion
- Emergency Situations

Sources

- Video analysis
- HMI
- Supervisors

Abstract 2c. Data Content standard and data aggregation across supply chain – Briefed by Cass Wade-Kudla

Concept for funding: Field to Fork Proof of Concept- technology and data definition - one single commodity and processor to identify key data content/attributes from seed to consumer. FSMA overlay? Data standardization for ingredients similar to Australia.
Process: develop dashboard to determine what data content is needed to enhance food safety, quality, transparency and efficiency. Could feed Smartlabel, ecommerce.
Content: all parameters in specs (raw material and finished product) – outputs of analytical measurements, not recipes. Collected by the owner of materials, and processes. Proprietary information should be limited in scope.

Key outcomes:

- End to end traceability and transparency
- Quicker response time to food safety issues
- Correlation of performance to capabilities, real time learning for AI purposes; i.e. adjust based on moisture level, etc.

Abstract 2d. Augmented Reality Smart Worker – Briefed by Chris Paulsen

Goals: Determine which types of data would be most useful to present to process line operators (via AR head up displays) and define and quantify the measurable benefits.

Scope:

- Select a food processing operation to pilot the concept
- Audit the operation and operators to determine candidate data
- Generate a system specification, RFP, bid out and procure pilot system
- Develop and Implement pilot project
- Capture and document results
- Develop generic specification for use in scaling the application.

Table 2. AI and A/VR Abstract Scoring

Abstract	Title	H	M	L
2a	Cloud-Based Data Structure	3	3	0
2b	Data Flow at the Shop Level	8	5	3
2c	Data Content standard and data aggregation across supply chain	12	4	0
2d	Augmented Reality Smart Worker	4	13	1

Topical Area 3. Advancing Process Technologies for Safety and Efficiency

This group discussed process technologies that would improve food safety and efficiency. The ideas of the group centered around configurability and knowledge management. A common theme emerged around modeling and digital twins of food production processes to manage the uncertainty in processes.

Abstract 3a. Line configuration – Briefed by Scott Sandler

We need agility and flexibility in our food manufacturing systems. One way to address this is the use of reconfigurable lines. The proposal is to develop a modeling system for process configuration that takes into account variation of raw materials, energy availability, water availability, quality, quantity and safety.

There is a need for validating the model through simulation, with demonstrated industrial design accounting for human, food and environmental safety. It must deliver product performance and be scalable and efficient. The design should also be validated with analytics and fielded systems.

Abstract 3b. Dynamic Recipes – Briefed by Mark Besser

Create a dynamic recipe /condition management system which can sense and react to changing conditions in a manufacturing process. (Digital twin?)

Scope to include:

Inputs:

- Ingredient Properties / Compositions
- Moisture
- Proteins
- Viscosity
- Measurements
- Time sensitive
- Age
- Rate
- Representative
- Precision
- Environmental
- Weather
- Air quality

Model:

- Machine Learning

- Stoichiometry (calculation of reactants and products in chemical reactions)
- Equipment Modeling
- Heating
- Coating
- Grinding/Polishing
- Etc.
- Control / Automation
- Human & Machine

Simulation – Validation
Actuation – ASAP

Table 3. Advancing Process Technology Abstract Scoring

Abstract	Title	H	M	L
3a	Line Configuration	2	7	1
3b	Dynamic Recipes	7	3	3

Topical Area 4. Packaging and Sensors for Consumer Awareness and Information

This group focused on the consumer side of food safety through the discussion of packaging and integrated sensors for food safety. Two main thrusts were discussed: packaging materials and sensor integrated packaging.

Abstract 4a. Food Packaging – Briefed by Jason Robertson

With food waste in the U.S. growing to 52 million tons annually being sent to landfills and food recall costs estimated around $55 billion according to an Ohio State University study, we are interested in looking at innovations around food packaging that provides more data for the consumer as they make decisions at the grocery store shelf.

We are looking at assistance to research innovative packaging concepts that can address the following:

- Food Safety
- Quality/Nutritional
- Shelf Life Management food safety

Additionally, product tampering is also a risk and this innovative package would include ways to show the consumer the package has been adulterated.

Key vendors would be selected to do R&D efforts for new packaging materials and tested by selected food companies.

Key Results would include:

- Less food waste
- Higher Consumer Confidence
- Higher quality/nutrition
- Elimination of recall

Abstract 4b. Packaging Sensors for Food Safety – Briefed by Cass Wade-Kudla

- Applicant chooses type of commodity for proof of concept:
  - frozen foods
  - Raw meats
  - leafy greens and/or vegetables or fruit
- Two sensors for two applications:
  - Transportation - temp abuse due to temperature changes not detected at destination
  - Retail consumer packaging - detection of pathogens

- Goal:
  - Prototype packaging systems available in 18-24 mos.;
  - cost can't be hurdle to consumer purchase or manufacture application
  - must have redundancy in reliability
  - need to detect top pathogens within period of time that would enable more control by processor
  - Detect most common pathogens in targeted product for consumer
- Advantages:
  - if caught at transportation – minimize recall issue
  - For consumer, minimize illness, and provide control
  - Promote trust from producer

Abstract 4c. Sensors for Packaging – Briefed by Bill Antoskiewicz

Study to develop a package with sensor technology that can measure "Environmental" levels (such as temperature, humidity, etc. changes) with capability to notify (e.g. package color-permanent) that the product has exceeded an acceptable range for consumption.

Table 4. Packaging and Sensors for Consumer Awareness and Information Abstract Scoring

Abstract	Title	H	M	L
4a	Food Packaging	6	6	4
4b	Packaging Sensors for Food Safety	4	3	1
4c	Sensors for Packaging	1	7	7

Post Workshop Survey Results

As mentioned above, a post workshop survey of the workshop participants was performed. 12 out of 35 attendees returned the survey. The survey results are attached in Appendix C.

Overall, the survey showed satisfaction with the workshop with 10 respondents indicating that the workshop met or exceeded their expectations. Several comments indicated that more coordination with existing industry associations and efforts are needed to complete this prioritization. A large majority of the respondents appreciated the networking opportunities developed at the workshop and over half were interested in joining CESMII or leveraging their existing relationship with the Institute.

In assessing pressing business issues, the survey respondents ranked food safety as the most important issue followed by supply concerns. Data analytics and Sensors ranked highest in technology gaps. One respondent suggested that the workshop should have had additional concentration in modeling and AI to transform sensor data to usable information.

Summary:

The workshop was productive in developing Food Safety and Traceability project ideas and identifying partnerships to develop proposals in response to upcoming CESMII project calls. A total of 11 abstracts were developed and ranked. Some of the abstracts described projects that were substantially the same, and those scores are aggregated in the ranking.

Table 5. Abstract Aggregate Rankings

Abstract	Title	H	M	L
2c	Data Content standard and data aggregation across supply chain	12	4	0
2a	Cloud-Based Data Structure	3	3	0
3b	Dynamic Recipes	7	3	3
3a	Line Configuration	2	7	1
2b	Data Flow at the Shop Level	8	5	3
4a	Food Packaging	6	6	4
2d	Augmented Reality Smart Worker	4	13	1
1a	Sensors to detect contaminants	5	6	2
1b	Pathogenic Detection for Food Safety	4	4	3
4b	Packaging Sensors for Food Safety	4	3	1
4c	Sensors for Packaging	1	7	7

The highest priority indicated by the participants was around data standards and structures. Primary data requirements include food and ingredient quality metrics (as opposed to quantity metrics commonly used today. Implied in this topic is the ability to track the data across the

supply chain (traceability) as well. This topic originated from the AI group which also has the most interest in forming a development team.

The next highest priority had to do with managing uncertainty in ingredients as well as the ability to dynamically manage production line configurations. Topics discussed included platform requirements, digital twining of production lines, and the integration of analytics to manage product quality in the face of variability of ingredient characteristics.

Recommendation

CESMII and the TFM community form two affinity groups:

- Data Standards for Food Safety and Traceability. The charter of this group is to determine and suggest standard data fields for ingredient quality and contaminant characteristics. This should be in coordination with existing industry activities already underway (e.g. Grocery Manufacturers Association – Smart Label Initiative)
- SM Platform Requirements and Implementations for Food Safety and Traceability. This group would examine the food manufacturing problem form the platform point of view and put in place plans for the development of platform components and products to create process digital twins and the associated analytics to manage product safety with follow-on applications for dynamic recipe management.

Appendix A: Workshop Attendees

TFM/CESMII Food Safety and Traceability Workshop August 1, 2018 Attendance List		
First Name	Last Name	Primary Email
Francesco	Aimone	FAIMONE@inductionfoodsystems.com
Bill	Antoskiewicz	bill.antoskiewicz@savigent.com
Mark	Besser	mark.besser@savigent.com
Jill	Brigham	jbrigham@ucdavis.edu
Shane	Colella	shane@colelladigital.com
James	costa	jcosta@sneakz.com
Kenneth	Creasy	kcreasy@its.jnj.com
Christopher	Damsgard	Chris.Damsgard@genmills.com
Wayne	Daley	wayne.daley@gtri.gatech.edu
Richard	Donovan	rpdonova@uci.edu
Peter	Edwards	peter.edwards@conagra.com
Simon	Frechette	simon.frechette@nist.gov
Danielle	Gray	danielle@dgmarketingco.com
Adam	Harris	harris.adam@siemens.com
Joe	Heinzelmann	jheinzelmann@neogen.com
Ryan	Jarvis	ryan.jarvis@siemens.com
Richard	King	richard.king@genmills.com
G.p.	Li	gpli@uci.edu
Nathan	Miller	nathan_miller@cargill.com
Christopher	Paulsen	Cpaulsen@wepcoinc.com
Cami	Persson	cami.persson@siemens.com
Michael	Reck	mike.reck@grantek.com
Jason	Robertson	jason.robertson@crbusa.com
George	Sadler	gsadler@inductionfoodsystems.com
Scott	Sandler	scott@thinkiq.com
Joe	Sanguinetti	joe.sanguinetti@genmills.com
Dean	Schneider	dean.schneider@cesmii.org
Ann	Seman	ann.seman@cesmii.org
Robbin	Shoemaker	rshoemaker@nifa.usda.gov
Walt	Staehle	walter.staehle@siemens.com
Kelly	Stevens	kelly.stevens@genmills.com
Cheng	Sun	c-sun@northwestern.edu
Cass	Wade-kudla	cass.wade-kudla@genmills.com
Vaishali	Wagher	vaishali.wagher@genmills.com
Timothy	Wei	twei3@unl.edu
Jim	Wetzel	jim.wetzel@cesmii.org

Appendix B: Agenda

July 31, 2018 – Minneapolis Marriott West; 9960 Wayzata Blvd

7:00 – 9:30 pm	***Reception*** There will be a briefing on TFM and CESMII for first-time attendees at 20:00.

August 1, 2018 - General Mills World Headquarters

8:00 – 8:20 am	***Registration and Continental Breakfast***
8:20 – 8:30	***Welcome*** *John Church, Executive Vice-President, Supply Chain & Global Business Solutions*
8:30 – 8:45	***Introductions*** *Dean Schneider, CESMII Southern Region, Texas A&M Energy Institute; Tim Wei, University of Nebraska – Lincoln, TFM*
8:45 – 9:15	***Getting Out of the Blocks: Framing the Day's Discussions*** *Tim Wei, University of Nebraska – Lincoln, TFM*
9:15 – 10:15	***Breakout Sessions: Small Group Discussions*** • Process Sensors Technologies for Food Safety and Security (1) • Artificial Intelligence and Virtual/Augmented Reality for Design and Analysis (2)
10:15 – 10:25	***Break***
10:25 – 11:15	***Breakout Sessions: Full Group Discussion*** • Process Sensors Technologies for Food Safety and Security (2) • Artificial Intelligence and Virtual/Augmented Reality for Design and Analysis (1)
11:15 – 11:35	***Session Report Outs***
11:35 – 12:45	***Networking Lunch***
12:45 – 1:45	***Breakout Sessions: Small Group Discussions*** • Advancing Process Technologies for Safety and Efficiency (1) • Packaging and Sensors for Consumer Awareness and Information (2)
1:45 – 2:35	***Breakout Sessions: Full Group Discussions*** • Advancing Process Technologies for Safety and Efficiency (2) • Packaging and Sensors for Consumer Awareness and Information (1)
2:35 – 2:45	***Break***

2:45 – 3:05	***Session Report Outs***
3:05 – 3:30	***Overview/Opportunities at USDA-NIFA*** *Hongda Chen, USDA-NIFA*
3:30 – 4:30	***Next Steps/Closure: Integrating Data and Communication Across the Supply Chain*** *Chris Paulsen, CEO Pulse Integration*
4:30	***Adjourn***

Appendix C: Post Workshop Survey Results

Total Number of Returned Surveys: 12 out of 35 attendees

1. Evaluation of expectations:

Did not meet expectations	0	Somewhat met expectations	2	Met expectations	4	Exceeded expectations	3	Highly exceeded expectations	3

2. Please let us know what you liked about this workshop.
   - Interactive and thought process platform (unclear)
   - Network, discussions
   - Meeting others from industry
   - Very capable people coming together
   - Interactive
   - Great mix of talent and expertise
   - Provided a very good perspective on food industry issues with respect to data sciences
   - Great Program!
   - Breakouts
   - I did not think that we would get to such concrete ideas as we did. The abstract idea/approach was helpful
   - Great insight into SM from various viewpoints, industries
   - Well attended and lots of great ideas and experience

3. Please let us know what you did NOT like about this workshop
   - Long, not well organized in structure
   - Lack of awareness of other related activities happening in the trade associations
   - Should have been more benchmarking at the workshop; not as part of the workshop but some time to learn from one another (non TFM participant)
   - A little too GM centric
   - At times there was a lack of clarity in direction
   - Needs more food companies participating
   - Not enough newer/younger professionals involved

4. Why did you attend this workshop?

Beginning to research SM practices	0	Beginning to implement SM practices in my organization	2	Interested in learning more about CESMII and its goals within this industry	6	Opportunity to leverage CESMII membership	6	Networking Opportunity	8
Other responses Present NIFA funding Opportunity CESMII Membership participation opportunity									

5. What keeps you up at night? That is what areas in terms of technology gaps are you most concerned about addressing? Please rank on scale of 1 to 5, 5 being most concerned about this gap, 4 = concerned, 3 = neutral, 2 = less concerned, 1 = least concerned

Gap	**n**	**σ**	**Gap**	**n**	**σ**	**Gap**	**n**	**σ**
Supply	9	3.33	Safety	11	4	Security	10	3.2
Other responses Staying Competitive – 4 Productivity/Efficiency – 4 Traceability Profitability								

6. What are your current technology gaps areas? Please rank on scale of 1 to 5, 5 being most concerned about this gap, 4 = concerned, 3 = neutral, 2 = less concerned, 1 = least concerned

Gap	**n**	**σ**	**Gap**	**n**	**σ**	**Gap**	**n**	**σ**
Automation & Control	9	3.6	Sensors	9	3.9	Data & Analytics	10	3.9
Antimicrobial Materials & Coatings	8	3.6	Codes & Standards	10	3.0	Workforce	10	3.5
Public Policy	10	3.3						
Other responses None								

7. Please indicate any additional thoughts that were not sufficiently covered in the workshop:

Comments:

a. Some of the CESMII imperatives and clean energy did not find their way directly into most conversations
b. Modeling and AI to transform sensor data to usable information

8. Next Steps: Would you be interested in participating in a project development effort around one of the workshop topics? If so, please indicate the topic and identify yourself so we can form the team.

Process Sensors Technologies for Food Safety and Security

Name	Organization	Email
Joe Sanguinetti	General Mills	joe.sanguinetti@genmills.com
Ken Creasy	Johnson & Johnson	kcreasy@its.jnj.com

Artificial Intelligence and Virtual/Augmented Reality for Design and Analysis

Name	Organization	Email
Vashali Wagher	General Mills	vaishali.wagher@genmills.com
Joe Sanguinetti	General Mills	joe.sanguinetti@genmills.com
Cass Wade-Kudla	General Mills	cass.wade-kudla@genmills.com
Richard King	General Mills	richard.king@genmills.com
Chris Paulsen	Pulse Integration	Cpaulsen@wepcoinc.com
Chris Damsgard	General Mills	Chris.Damsgard@genmills.com
Peter Edwards	Conagra Brands	peter.edwards@conagra.com

Advancing Process Technologies for Safety and Efficiency

Name	Organization	Email
Joe Sanguinetti	General Mills	joe.sanguinetti@genmills.com
Richard King	General Mills	richard.king@genmills.com
Chris Damsgard	General Mills	Chris.Damsgard@genmills.com

Packaging and Sensors for Consumer Awareness and Information

Name	Organization	Email
Joe Sanguinetti	General Mills	joe.sanguinetti@genmills.com
Jim Costa	Sneakz Organic	jcosta@sneakz.com