Agriculture 4.0; Connecting the Field to the Internet

FarmSmart Conference
Saturday, January 23, 2016
Prairie Meadows Events Center

S.A. Shearer
Food, Agricultural and Biological Engineering
**Iowa AgState Task Force**

*digital agriculture* – family of activities related to farming that includes *precision agriculture*, *prescription agriculture* and *enterprise agriculture*; and depends on the collection, use, coordination, and analysis of data from a multiplicity of sources with the goal of optimizing productivity, profitability and sustainability of farming operations.
Big Data

NSF recently referred to Big Data as large, diverse, complex, longitudinal, and/or distributed data sets generated from instruments, sensors, internet transactions, email, video, click streams, and/or all other digital sources.

What is the value of “Big Data” if we don’t produce actionable information?
Technologies that will shape the future of agriculture...
Topcon Positioning Systems IP-S2 HD

http://www.topconpositioning.com/products/mobile-mapping
What Is Watson?

Watson is a cognitive technology that processes information more like a human than a computer—by understanding natural language, generating hypotheses based on evidence and learning as it goes.

Watch the video
Google Car

http://www.extremetech.com/extreme/147940-google-self-driving-cars-in-3-5-years-feds-not-so-fast
Market forces that will shape the future of agriculture...
Big Update: The Truth That Beer Companies Have Not Made Public Yet

By Food Babe

On June 11, 2014, I launched a petition to ask 2 major beer companies – Anheuser-Busch and MillerCoors to disclose their ingredients online. The alcohol industry lobbied for years to keep this information secret from us – and now finally, due to your support, signatures and activism, we’re finally going to get some information. The Food Babe Army succeeded where other organizations have not. To think beer companies have gotten away with this for decades is mind-boggling.

"This is pretty incredible. 24 hours, and 43,000 signatures after her petition went online, Vani Hari, aka the "Food Babe," has convinced Anheuser-Busch to publicly reveal the list of ingredients for its beers. To put that into context, the Center for Science in the Public Interest has been lobbying the government to require beer companies to list their ingredients — something they’re not currently required to do by law — for three decades." – Salon

I am so amazed by the power of the FoodBabeArmy. What we have done is truly astonishing. In just one day, we received not only responses from these huge multi-billion dollar corporations, but they are already taking steps in the right direction and beginning to publish their ingredients online. But the fight is not over. I’m still going to need you to pay attention and learn the facts about what’s happening right now. I spent last weekend gathering this critical information to share with you – I want you to have all the details.

On the afternoon of June 12, 2014, I received a phone call and a letter from Anheuser-Busch, in which they told me that they will agree to publish their ingredients online at TapIntoYourBeer.com and invited me to meet with their head brewers in St. Louis. When I heard the news, I was obviously thrilled (one of my lovely team members took a photo right at that moment, see below). I had been thinking and preparing for this petition for almost a year and was honestly quite shocked at the fast response.
Managing the Supply Chain – Corn Syrup

**Fertilizer and Nutrients** - Improper management and use of fertilizers can lead to local water pollution and release greenhouse gases during production. *Growers should use a nutrient management plan to improve the efficiency of fertilizer and manure use for production. Growers can use precision agriculture, which applies only the amount of fertilizer needed.* Where appropriate, growers could plant vegetative buffer zones around streams to help prevent water pollution via nutrient runoff.

**Land and Soil** - Improper soil management can remove nutrients, release greenhouse gases, and cause soil loss, while clearing land for agriculture can lead to deforestation. *Growers should use efficient soil management practices, including reduced soil tilling when applicable and prevention of soil erosion.* Manufacturers should use sourcing policies that monitor progress on zero deforestation commitments. Sourcing policies should also promote protection of high conservation value forest habitats, which have unique plants and animals. This reduces the risk of biodiversity loss, diminished ecosystem quality, and increased greenhouse gas emissions that can occur when forests are cleared for agriculture.
Current precision ag technologies...
What’s driving planter development?
Precision Planting Sensing and Control
Case IH and AGCO agreements....
Kinze Multi-Hybrid
CleanSeed CX-6 Smart Seeder

(Source: http://www.cleanseedcapital.com/index.html)
Controlling Canopy Architecture
Torres, Vossenekemper, Raun and Taylor (Oklahoma State University)
OSU/Beck’s Field Investigations
Telematics offerings...

John Deere FarmSight™
John Deere Tractors equipped with JDLink™ let you monitor machine performance from any internet-accessible location such as your desktop or smartphone. With your permission, your dealer can proactively support and diagnose issues, which saves you time and money.

Connected Farm
Interactive 3D Tour
Experience the power of the Connected Farm solution.

Farmobile

TOTAL COVERAGE
We have your back.

THE OHIO STATE UNIVERSITY
Fuel Use Rate Distributions

**Planting**

![Graph of Fuel Use Rate (L/h) for Planting]

**NH₃ Application**

![Graph of Fuel Use Rate (L/h) for NH₃ Application]
How big is too big?

https://www.bauerbuiltmfg.com/db-series-planters.html
Spray Application Accuracy

(Fulton, et al.)
Trends in ballasted GVW?

Note: Maximum tractor weight is increasing at a rate of 900 lb/yr.
500 Hp - 60,000 lb.

685 Hp - 78,000 lb.
Additional Concepts


http://farmofthefuture.net/#/slideshow/autonomous-tractors-take-field

http://www.ivtinternational.com/design_challenge_jon_pope_june_10.php
2015 North American Combines

**John Deere S690**
- Engine - 13.5 L, 543 hp
- Grain Tank - 400 bu
- Unload Rate - 3.8 bu/s
- Fuel Tank - 330 gal
- Base Mass - 45,856 lbs
- Head - 616C (9,900 lb)
- Loaded Mass - 79,587 lbs

**Case IH 9240**
- Engine - 15.9 L, 550 hp
- Grain Tank - 410 bu
- Unload Rate - 4.5 bu/s
- Fuel Tank - 317 gal
- Base Mass - 46,297 lbs
- Head - 4416 (11,800 lbs)
- Loaded Mass - 83,114 lbs

**Claas Lexion 780TT**
- Engine - 15.6 L, 543 hp
- Grain Tank - 385 bu
- Unload Rate - 3.8 bu/s
- Fuel Capacity - 304 gal
- Base Mass - 39,683 lbs
- Head - 16 row (11,070 lbs)
- Loaded Mass - 73,855 lbs
Combine Classes?

Class X – 565 hp
Class XI – 629 hp
Class XII – 693 hp
Class XIII – 757 hp

http://www.youtube.com/watch?v=WUXY4hQDtpI
North American Grain Carts

Balzer 2000/Brent 2096
Capacity – 60 ton
Total Loaded Mass – 76.4 ton
Unloading Time – 120 s

http://www.balzerinc.com/index_files/Page760.htm

http://www.agweb.com/assets/1/6/BrenAvalanche2096web.jpg
Trend in cart weight?

![Graph showing trend in cart weight](image)
Data driven decisions… the future of agriculture!
Agronomic and Machine Data Generation

- As-Applied Files (.shp)
  - Spraying [0.3 MB/ac]
  - NH₃ application [4.3 MB/ac]
  - Planting [5.5 MB/ac]
- Yield Data [4.3 MB/ac]
- Prescription Files [0.01 MB/ac]
- Soil/Fertility Data [0.6 MB/ac]
- Total [0.5 KB/plant (corn)]
- If 35,000 plants/acre (corn)
  - 17.5 MB/acre
  - 42.7 GB for 2,500 acres
Remote Sensing Data Generation

- 24 bits per pixel
- 2.5 cm/pixel
- 17.2 MB/ac of image data
- 4.9 kB/plant (corn)/yr
- If 35,000 plants/acre (corn)
- 429 GB for 2,500 acres
- 10 x data rate

https://www.sensefly.com
Herbicide Carryover

N Application Errors

Hybrid Differences
Precision Planting Singulation Map
High Resolution Imagery

Woolpert, Dayton, OH
Emergence/Stand Counts

- RGB Recognition of Corn and Corn Shadows
- Segmented Corn Blobs
- Smoothed 3D Visualization of Individual Corn Plants
- Automated Plant Counting
Multi-Hybrid Planter Set-Up
In-Field Dual Hybrid Evaluation

- Cooperators were identified and fields selected for planting
- Prescription maps were generated using FARMserver (test blocks were placed in fields to verify hybrid and population performance)
- Matching bulk fill fan speed with hybrid varies with weather conditions (same noted for vacuum fan)
High Resolution RGB and ADVI Images
Beck’s Multi-Hybrid/Variety ROI

<table>
<thead>
<tr>
<th>Kinze 4900 MH Planter</th>
<th>Precision Planting VSet Select</th>
</tr>
</thead>
<tbody>
<tr>
<td>• $29,185 or $1824/Row</td>
<td>• $31,200 or $1950/Row</td>
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Beck’s Multi-Year Data (2012-2014)

- Corn: +7.9 bu/ac, $42.77/ac
- Soybeans: +3.2 bu/ac, $38.48/ac, $40.63/ac

Break-Even Acreage
- Corn: 353 ac
- Soybeans: 392 ac
High Resolution RGB Images
Lightweight Hyperspectral Cameras

Rikola Ltd 300 g Hyperspectral Camera
500-900 nm (10 nm resolution)

Headwall Photonics Micro-Hyperspec (1.8 lb.)
400-1000 nm (324 bands)
Hyperspectral Measurements of Tassels

Hyperspectral Measurements of Silk
New Satellite Technology

113 Dove CubeSats (10 cm x 10 cm x 30 cm) now in orbit.
(Sources: spacenews.com and planet.com)
Telematics for Tracking Field Activities
Tracking grain carts?
2015 Compaction Study
Compaction Plots and Planter Downforce
2015 Compaction Study (RGB)
2015 Compaction Study (ADVI)

5-20-15

8-14-15

10-11-15
Crop Response to Traffic Events - Corn

<table>
<thead>
<tr>
<th>Traffic Event</th>
<th>Yield (bu/ac)</th>
<th>Yield Loss (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheeled</td>
<td>185.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>10.90</td>
</tr>
<tr>
<td>Tracked</td>
<td>202.2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.88</td>
</tr>
<tr>
<td>Control</td>
<td>208.2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>-</td>
</tr>
</tbody>
</table>
More grain cart tracking...
Grain Cart Traffic Pattern

500 bu. Grain Cart

1,000 bu. Grain Cart

2,000 bu. Grain Cart
“...we saw yield decrease by 19.6 bu. per acre between pinch rows and wing rows on a center-fill planter...” says Jason Webster... (Source: agweb.com)
Air seeders?

(Source: bourgault.com)
Sprayers?

(Source: northernequipment.ca)

(Source: oemoffhighway.com)
Continuing trend toward automation....
Current Products

Deere’s MachineSync

AGCO’s GuideConnect

http://www.deere.com

http://www.farms.com/FarmsPages/ChatDeshBoard/ChatThreadView
Autonomous Tractor vs. Baxter?

Future of Agriculture?
Future of ag production technology...
Integrated Data Platform for Crop Management

**NS Testbed**
**FSPR Testbed**
**UAVRS Testbed**
**DSS Testbed**
**Soil, Crop and Remote Sensing Databases**

**Micrometeorological Remote Sensing Root Zone Conditions Crop Conditions**
**Data at Varying Spatial and Temporal Scales**

**Data-Driven Machine Learning Algorithms**
**Spatial and Temporal Scaling**

**Field Scale Gridded Observations**

**Hydrologic Nutrient Crop Growth Models**
**Data Assimilation**

**Field Scale Predictions of Soil, Nutrient and Crop Conditions**

**Industry Platforms**

**Near Real-Time Field Scale Nutrient Management Decisions**

**Canopy Measurements**
- Ambient Temperature – Upper Canopy
- Wet-Bulb Temperature – Upper Canopy
- Ambient Temperature – Lower Canopy
- Wet-Bulb Temperature – Lower Canopy
- Incident Radiation – Upper Canopy
- Radiation – Lower Canopy
- Precipitation
- Leaf Chlorophyll Content
- Plant Growth Stage
- Plant Height

**Root Zone Measurements**
- Available Soil Moisture
- Soil Available N-P-K Levels
- Soil Organic Matter
- Soil pH
- N Root Uptake
- N Fertilization

**Remote Sensing Measurements**
- Leaf Area Index
- Biomass Accumulation
- Canopy Temperature
- Leaf Chlorophyll Content
- Plant Growth Stage

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Questions?

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