

January/February 2019

RESOURCE

engineering and technology for a sustainable world

Visual Challenge 8

“VIEW FINDER”

Also inside:

AE50 Award Winners

Ethics Essay Contest Winner

Balance in Your Early Career



The AE50 Awards and the Davidson Prize



As we turn the corner on another year and take a quick look back, the new technology entering the marketplace has been amazing. In this issue of *Resource*, you'll see some of industry's best new products recognized with AE50 awards. These innovations help farmers bring more nutrition to our tables with increased efficiency and quality. I congratulate the AE50 winners,

and I look forward to personally saluting the companies that have invested in product development at ASABE's Agricultural Equipment Technology Conference (AETC). This year's AETC is February 11-13 in Louisville, Kentucky, and if you have never attended, please consider going. AETC is a great technical conference, and it aligns with the National Farm Machinery Show, February 13-16. With one travel plan, you can experience a technical conference and a commercial trade show—a two-for-one deal! If you're like me, you're always looking to get more out of your travel, and AETC/NFMS hits a home run. (Sorry, I just couldn't miss a shout-out to our Louisville Slugger fans).

If you can't make Louisville, consider the next opportunity—the Commodity Classic, February 28 to March 2 in Orlando, Florida, where the 2019 Davidson Prize winners will be announced. In 2018, ASABE and Association of Equipment Manufacturers (AEM) struck up a partnership and hosted the inaugural presentation of the Davidson Prize in Anaheim, California. This award, named for J. B. Davidson, the father of modern agricultural engineering and founder of our Society, gives a nod to the best of the best. The submission material used for the AE50 awards will be the basis for evaluating and selecting, by an independent panel, the newly introduced products that are perceived to have a significant impact on agricultural production, efficiency, and/or safety improvements.

Both the Louisville and Orlando events drive our Society's mission to elevate awareness of what our members are doing to improve our world. I hope these new products and technology provide you with inspiration toward future innovations of your own.

Where does innovation really come from? As engineers, we see challenging problems everywhere, and we're always looking for inspiration to solve them. Some of us look to nature for ideas, others surf the internet. Alternatively, I would submit that we also look to our fellow ASABE members. We sometimes forget how diverse our membership is and what collaborations are possible. We have many technical interest groups, many of which are noncompetitive and pursue similar issues from different perspectives. Our member diversity is a key benefit to belonging to ASABE. Our members know about aquaculture, applied science systems, energy systems, ergonomics, sensors and controls, machinery, natural resources, environmental systems, plants, animals, facilities, and food processing. There is great diversity among our technical groups, but we all talk the same engineering language and have common experience in measuring, quantifying, and processing tied to the food chain. An ASABE technical group is probably considering new ideas for your particular area of concern.

I'm sorry to say that I don't have your next great idea in my pocket, but I'm happy that ASABE is working every day to bring you and your fellow members together to come up with the next award winner. Please take the opportunity to connect with other members. I think you will discover many new ideas, particularly if you attend an upcoming conference.

Congratulations as well to all those who submitted their great photos to the Visual Challenge, which is now in its eighth year. Impressed? You should be!

As always, if you have any thoughts or opinions for ASABE, I would appreciate hearing from you.

Maury Salz
msalz@myasabe.org

events calendar

ASABE CONFERENCES AND INTERNATIONAL MEETINGS

To receive more information about ASABE conferences and meetings, call ASABE at (800) 371-2723 or e-mail mtgs@asabe.org.

2019

Feb. 11-13 **2019 Agricultural Equipment Technology Conference.** Louisville, Ky., USA.

July 7-10 **ASABE Annual International Meeting.** Boston, Mass., USA.

ENDORSED EVENTS

Jan. 28-30 **53rd Annual Convention of Indian Society of Agricultural Engineers (ISAE).** Varanasi, U.P., India.

March 14-15 **The 12th TSAE International Conference & 20th TSAE National Conference.** Pattaya, Chonburi, Thailand.

March 18-22 **21st Century Watershed Technology and Vietnam International Water Week (VACI2019).** Hanoi, Vietnam.

RESOURCE

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ON THE COVER:

“Watch your fingers!” Inside the processing head of a Crumbler® rotary shear, where hardwood chips become precision feedstock for diesel conversion. Visual Challenge photo by ASABE member Dave Lanning, Senior Engineer, Forest Concepts, LLC, Auburn, Washington, USA.



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Resource is pleased to sponsor the AE50 awards recognizing new developments in agricultural and biological engineering. As in previous years, an expert panel selected the 50 products that ranked highest in innovation, engineering advancement, and market impact.

These products bring useful new technology to the field—saving producers time, cost, and labor while improving safety—and represent the diversity of agricultural, food, and biological systems.

Formal presentation of the AE50 awards will take place at ASABE's Agricultural Equipment Technology Conference, February 11-13, in Louisville, Kentucky. For more information on the AE50 awards program, visit www.asabe.org/ae50 or contact Sandy Rutter (rutter@asabe.org or 269-932-7004).



2660VT VARIABLE-INTENSITY TILLAGE

John Deere
Moline, Illinois, USA
www.deere.com

John Deere's 2660VT variable-intensity tillage tool provides a 0° to 12° gang angle range to adapt to changing field and soil conditions. The self-sharpening Commander™ blade retains a sharp edge to cut, size, and pin residue at a lower gang angle, while residue is mixed and buried at a higher gang angle. The double-cut edge provides superior soil penetration in hard conditions. An expansion of the ProFinish™ leveling system offers double hydraulic rolling baskets that leave a level and consistent field finish. Integrated TruSet™ tillage technology allows on-the-go adjustments with the in-cab display. The 2660VT has working speeds up to 10 mph, which can cover up to 60 acres per hour, and it folds compactly for transport.

3D SPRAY NOZZLE

Pentair-Hypro
New Brighton, Minnesota, USA
www.pentair.com

The 3D Spray Nozzle is an inclined, all-purpose nozzle designed for optimum spray coverage. The nozzle was developed using more than ten years of application and wind tunnel research to optimize the droplet spectrum and spray incline angle to provide maximum coverage. It was co-developed with Syngenta and has been proven in field trials to provide a 10% increase in pre-emergence weed control. The 3D Spray Nozzle comes standard with the new "SnapLock" cap that attaches more easily to nozzle bodies, requiring 73% less torque than the standard nozzle cap. This is also the first flat-fan nozzle to achieve LERAP drift reduction, with 60% to 75% drift reduction compared to a conventional flat-fan nozzle at low pressure.



700FD HYDRAFLEX™ DRAPER

John Deere
Moline, Illinois, USA
www.deere.com/en/harvesting/drapeer-platforms/

700FD HydraFlex™ drapers feature several improvements: larger full-length top augers deliver better feeding performance in bushy crops like canola; improved center feed sealing reduces losses in canola by up to 45%; and the dual-position feed drum allows greater throughput and smoother feeding of thick crop mats. Ground sensing is improved when cutting off-ground with the addition of a fourth sensor for header height sensing on wider heads (35, 40, and 45 feet). A symmetric side belt design with a thicker corrugated front edge increases belt life. The HydraFlex™ hydraulic float system continues to offer superior ground following performance and ease of adjustment for on-ground cutting while enabling a quick conversion to rigid mode for off-ground cutting.

ACTIVE HEIGHT CONTROL

Amity Technology
Fargo, North Dakota, USA
www.amitytech.com

Active Height Control (AHC) allows producers to more accurately and consistently defoliate their sugar beets ahead of their harvester. Using new technology that senses the tops of the sugar beets, AHC adjusts the height of the machine to keep the defoliator at the proper height as the machine moves through the field. During operation, there are a number of changing dynamics for ground level and sugar beet height, including uneven beets, sprayer tracks, and mud building up on the tires. Amity's AHC system constantly monitors the beet height relative to the ground level and adjusts the defoliator up and down as well as side to side. AHC provides full defoliation with less damage to sugar beet crops.





AGRICULTURAL DATA APPLICATION PROGRAMMING TOOLKIT (ADAPT) FRAMEWORK AND ISOXML PLUGIN

AgGateway
Washington, D.C., USA
AgGateway.org and ADAPTFramework.org

ADAPT is a set of open-source software libraries that implement a common data model for farming operations, coupled with a system of plugin libraries (including the ISO 11783-compatible "ISOXML plugin") that convert between the common object model and various formats of interest. All segments of the agricultural industry that either use or create field operations data will benefit from ADAPT, especially as leveraging data becomes critical for advancing productivity, efficiency, and sustainability. ADAPT was created through a collaborative effort of many manufacturers and developers throughout the industry, and is stronger as a result. As an international open-source project, ADAPT is offered free of charge for developers to adopt into their proprietary systems, to the benefit of growers.



A-SERIES APPLICATOR

Fast Ag Solutions, Inc.
Windom, Minnesota, USA
www.fastsprayers.com

The A-Series Applicator is towed behind a tractor to apply liquid nitrogen into or on top of the soil. The major benefit of this patent-pending product is its ability to fold from its 66-foot working width to only 12-foot transport width and 12-foot transport height, which allows operators to travel safely on public roads. The product tank and toolbar folding scheme on the A-Series Applicator were specifically designed to allow better rearward visibility from the tractor operator's seat. This helps the operator see other vehicles behind the applicator and helps approaching vehicles see the operator. The 12-foot transport height reduces the risk of hitting low bridges, shed doorways, and overhead powerlines.



AXIAL-FLOW® 250 SERIES COMBINE

Case IH
Racine, Wisconsin, USA
www.caseih.com/northamerica/en-us/home

The Case IH Axial-Flow® 250 Series combine, available with optional AFS Harvest Command™ automation, allows inexperienced operators to achieve expert performance. The 250 Series features a redesigned ground drive and numerous feeder improvements with increasing header lift and capacity. The new ground drive improves efficiency with on-the-go speed range toggling and fewer gear shifts, and drive power has been significantly increased. The redesigned feeder house features improved durability and increased throughput. The new feeder also includes optional in-cab faceplate fore-aft tilt control. The AFS Harvest Command™ automation system optimizes combine performance by preventing losses before they occur. Inexperienced operators using AFS Harvest Command™ typically see a 10% capacity increase compared to manual operation.



BALE MOBILE

John Deere
Moline, Illinois, USA
www.deere.com

From baling to loading to planning, the industry-exclusive John Deere Bale Mobile application gives customers the ability to track baling performance, monitor bale quality, and retrieve bales efficiently. The John Deere 1-Series Large Square Baler measures moisture and weight as each bale is formed. Using GPS, Bale Mobile acquires real-time bale information, similar to the yield data that's long been available for crops like corn and soybeans. Moisture and weight are tied to individual bales, and the Bale Mobile app also lets customers tag bales for identification during sorting. During baling, the app can show the locations of multiple balers and monitor their productivity. After baling is completed, summaries are available by field.



AFS SOIL COMMAND™

Case IH
Racine, Wisconsin, USA
www.caseih.com

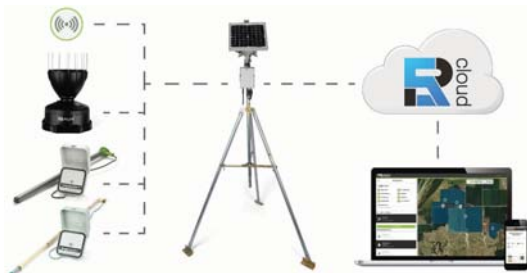
The Case IH AFS Soil Command™ agronomic control system uses sensors and electro-hydraulic controls to allow producers to monitor and control Case IH tillage tools from the tractor cab. This technology allows coordinated adjustments of tillage tools for optimized productivity and helps producers overcome unseen challenges to a field's full agronomic potential. Producers can use this technology to identify and correct misadjusted implement settings to enhance soil conditions in every tillage pass. AFS Soil Command™ is offered as an optional feature on Case IH's disk ripper, disk harrow, vertical tillage, and field cultivator product lines. The user interface is an ISOBUS Virtual Terminal (VT) application, enabling it to work with other tractor OEMs as well as aftermarket displays.



COMMANDPRO™ CONTROL FOR 6R SERIES TRACTORS

John Deere
Moline, Illinois, USA
www.deere.com

CommandPRO™ delivers a new way of driving a tractor with an ergonomic and intuitive operator experience. CommandPRO™ was designed for customers who want tractor operation and implement control in the palm of their hand. The operator can control travel direction and wheel speed (including active zero speed and inching) using the joystick, and can seamlessly change between pedal and joystick operation based on their application needs and preference. CommandPRO™ offers reconfigurable controls, ISOAux capability, and Settings Manager to enable application-specific setup. CommandPRO™ can be customized to support a variety of tasks related to livestock, hay production, roadside mowing, transport, snow removal, and row crops.



CONNECTIVITY PLATFORM

RealmFive, Inc.
Lincoln, Nebraska, USA
www.realmfive.com

RealmFive™ is changing the way customers interact with agricultural technology in areas including agronomy, inventory, irrigation, livestock, and machinery. RealmFive's Connectivity Platform has solved the problem of expensive and unreliable wireless connection to multiple types of sensors in tough crop canopy and noisy RF environments. Using highly improved long-range radio technology and easy-to-deploy devices, RealmFive enables remote monitoring, control, and data-driven decision-making. The RealmFive Connectivity Platform is modular and flexible, allowing simple third-party integration into the platform and a robust API to other digital farming platforms. With an expanding portfolio of applications including soil moisture, weather, irrigation monitoring, and state monitoring, RealmFive is bringing sensor-to-cloud solutions to agriculture.

CONVIO FLEX DRAPER

CLAAS of America Inc.
Omaha, Nebraska USA
www.claas.com

The new CONVIO Series of flex drapers features a fully flexible cutter bar, dual side belts and center feed belt, a feed drum with adjustable retractable fingers, and a split cam-action flip-over reel. All models feature CLAAS-exclusive AUTO FLEX and AUTO BELT SPEED technology to automatically optimize cutter bar flex according to ground conditions (in flex mode) and automatically adjust side and center belt speeds according to ground speed. The cutter bar can automatically alternate between rigid and flex modes when harvesting between standing and lodged grain crops. The CONVIO Series comes in 30, 35, 40, and 45 foot widths, and each model comes standard with dual (left and right) cutter bars and epicyclic knife drive.





CRUMBLER® P24M-150e-2 SYSTEM

Forest Concepts LLC
Auburn, Washington, USA
www.forestconcepts.com

The Crumbler® P24M-150e-2 System is the first commercial-scale rotary shear designed to process 7 to 10 dry tons per hour of raw biomass into precision, flowable particles for producing energy pellets, biochemicals, biofuels, and other bioproducts. The Crumbler® P24M-150e-2 is unique in that it processes high-moisture feedstocks using very low energy and without the need to pre-dry the biomass. The Crumbler® has two rotary shear heads stacked vertically to allow stepdown size reduction, which allows 98% conversion to reactor-ready feedstocks in a single



pass. PLC-controlled, the Crumbler® can process a variety of raw materials, including wood chips, corn stover, switchgrass, bamboo, sage, and many more, into uniform particles that can optimize conversion efficiencies.

DEHYTRAY™

JUA Technologies International LLC
West Lafayette, Indiana, USA
www.juatechnology.com

The DEHYTRAY™ dehydration tray is a simple solar-drying device that requires minimal setup time, is easy to clean or sanitize, easily handles different types of products (fruits, vegetables, granular cereals, meat, and fish), meets high ergonomic and aesthetic norms, and achieves faster drying than traditional



open-sun drying. Temperatures inside the DEHYTRAY™ are doubled compared to ambient, thereby achieving a faster drying rate, especially on cloudy days. The clear cover allows maximum exposure of the product to solar energy, protects the crop from pilferage by livestock or rodents, and protects the crop from rain. Easily replaceable photo-selective sheets can filter UV radiation for preservation of product color. The DEHYTRAY™ can easily be moved from one location to another.

DELAVAL VOLUNTARY MILKING SYSTEM VMS™ V300

DeLaval
Bannockburn, Illinois, USA
www.DeLaval.com

The DeLaval Voluntary Milking System VMS™ V300 is a milking robot that allows each cow to be milked according to her individual needs and capacity. The system includes DeLaval InControl™, a user interface for improved remote access to the milking system; DeLaval PureFlow™, a teat cup that cleans and prepares teats for milking with a transparent design that allows the dairyman to verify teat preparation; and DeLaval InSight™, a machine vision technology that ensures fast and accurate attachment of the cups to the cow. The DeLaval Automatic Milking System

(AMS) Service Tool allows service technicians to connect wirelessly to the VMS™ V300 to view, test, and calibrate all robotic systems, as well as valves, pumps, and sensors.



EVAKUULA

Smallholder Fortunes and Thermogenn
Kampala, Uganda
www.facebook.com/Evakuula/

Powered by renewable energy (wind and biogas), EvaKuula preserves the freshness of the evening milk for sub-Saharan smallholder farmers who don't have access to grid electricity, so the milk can be sold the next day. "EvaKuuling" is a two-stage process. The first process, called thermization, involves mild heating of the milk with biogas. The heat is low enough to not pasteurize or boil the milk. The second process, evaporative cooling, lowers the milk temperature to approximately 10°C below room temperature. This solution features two innovations. First, the thermization process has been scaled down to 20 liter capacity for use on smallholder farms. Second, thermization is seamlessly coupled with evaporative cooling. "EvaKuuled" milk passes all standard measures for freshness.





FENDT IDEAL COMBINE

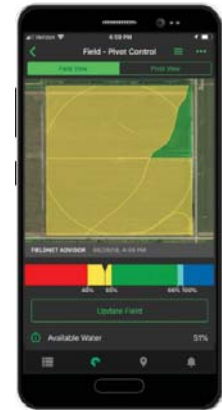
AGCO Corporation
Duluth, Georgia, USA
www.agcocorp.com

The Fendt IDEAL combine is the first clean sheet design that has entered the market in several decades. AGCO has taken a global approach in the design, using expertise from around the world to provide in-field efficiency, premium grain quality, reliable uptime, and simple operation. The IDEAL combine comes to North America after one of the most thorough field-testing programs in AGCO's history. Dual-helix rotors provide lower loss levels and ensure gentle crop handling. A combination of specialized sensors provides a real-time view of crop flow within the machine. An unload rate of six bushel per second paired with a grain bin capacity of 485 bushels ensures that grain handling logistics will not restrict operating efficiency.

FIELDNET® MOBILE IRRIGATION SCHEDULING

Lindsay Corporation
Omaha, Nebraska, USA
www.myfieldnet.com

FieldNET® by Lindsay has released a new mobile software application for iOS and Android that combines all the benefits of FieldNET® remote control and monitoring capabilities, FieldNET® Advisor's irrigation decision support and variable rate irrigation (VRI) prescriptions, and GrowSmart® Precision VRI optimization into a seamless application that can be accessed anywhere via a smart mobile device. With FieldNET® for iOS and Android, growers now have access to three irrigation management technologies that can increase their water and energy savings. They can monitor the status of their irrigation systems, view the irrigation prescriptions provided by FieldNET® Advisor, update and edit their GrowSmart® Precision VRI plans, and control their irrigations systems with a single, intuitive user interface and an enhanced level of mobility.



GEN4 COMMAND CENTER™ MACHINE PERFORMANCE APP

John Deere
Moline, Illinois, USA
www.deere.com

The Gen4 CommandCenter™ Machine Performance App installs on the 4600 Command Center and uses JDLINK™ wireless technology to communicate with the MyOperations™ mobile app anywhere in the world. The Machine Performance software helps maintain optimum combine performance. With labor shortages being a problem

for growers around the world, remote management of work quality is critical. The MyOperations™ mobile app with the Machine Performance software makes remote management possible. The additional features added to the MyOperations™ mobile app supplement the many current features, which are targeted at helping growers optimize their operations. The Machine Performance software takes optimization to the next level by giving remote users access to machine parameters through a mobile app on any smart device.



GROWFILM® CARTRIDGE

Grow Lites LLC
Eden Prairie, Minnesota, USA
www.growfilm.ag

GrowFilm® is a flexible LED light source that uses proprietary, patented technology and custom light spectra to shorten growing times and increase yields in controlled environmental agriculture. GrowFilm® is mounted on a thin backing that can be tiled to meet any size, configuration, or form factor. Because GrowFilm® produces minimal heat, it does not require heat sinks and can be placed closer to the plants than other light sources, providing optimum distribution of light. The result is the highest efficacy rating of any commercially available grow light, lowering the cost per pound for growers. This product was developed in consultation with the University of Minnesota's Department of Agriculture and has been extensively field tested.



GSI DRY/COOL PORTABLE QUIET DRYER AND GSI QUIET TOPDRY

GSI (Grain Systems, Inc.)
Assumption, Illinois, USA
www.grainsystems.com

GSI introduced two new grain dryers in 2018: the Dry/Cool Portable Quiet Dryer, which heats grain in the top plenum of the dryer to reduce moisture and cools grain in the bottom plenum, and Quiet TopDry, a combined drying and storage unit that dries grain in an upper chamber and then drops it into a lower compartment for storage. Both models incorporate GSI's Quiet Dryer technology, which reduces the noise level by 50% compared to conventional grain dryers. Two new components were also incorporated: the unique GSI UV Flame Sensor for both dryer models, and industry-leading GSI TopDry Terminal Manual Batch Control for the Quiet TopDry. Both components are designed to promote improved dryer performance and harvest efficiency.



GSI Z-SERIES™ BINS WITH FLEXWAVE® TECHNOLOGY

GSI (Grain Systems, Inc.)
Assumption, Illinois, USA
www.grainsystems.com/z-series

GSI's new Z-Series™ Bins with Flexwave® Technology offer farmers a safer, more efficient, and less labor-intensive option for unloading their grain bins. Standard grain bins are typically emptied with a combination of gravity flow and sweep augers, but there's always some amount of grain left on the bin floor that needs to be removed with brooms or shovels. It's hard, dusty, time-consuming work that can also be dangerous if farmers perform this chore while the sweep auger is still running. The Z-Series Bins use large liners made of durable fabric that alternately inflate and deflate to gently push the grain into a central reclaim area for removal, providing 99.9% cleanout without requiring farmers to enter the bin.



GUSS

GUSS Automation
Kingsburg, California, USA
www.GUSSag.com

GUSS (Global Unmanned Spray System) is the world's first autonomous orchard sprayer. A single operator can monitor up to ten GUSS sprayers at a time with a laptop and a cellular connection. GUSS uses a combination of sensors, including an onboard camera, obstacle detection, and an impact-sensing bumper, to drive itself through the orchard. In addition to the obvious benefit of labor reduction, GUSS excels in application precision, efficiency, and safety. Exact parameters are programmed for each application, including vehicle speed, material flow rate, and fan speed. Efficiency is maximized by reducing the amount of downtime and eliminating human error. GUSS is safer than tractor-pulled sprayers because it eliminates the possibility of exposing the driver to the spray.

helioCORE™

Heliospectra AB
Gothenburg, Sweden
www.heliospectra.com

helioCORE™ is a light control software system that pairs artificial intelligence with sensor technology and adjustable spectrum Heliospectra LEDs to create real-time, dynamic light response in greenhouses and indoor controlled growing environments. helioCORE allows growers to apply precise amounts of supplemental lighting based on plant needs, as well as forecast



yields, ensure consistent crop quality and production, and achieve advantages in the retail marketplace. For commercial-scale operations, predicting the exact yield is key for success. helioCORE delivers actionable, data-

driven insights to growers to automate every parameter of the lighting environment. This has significant positive impacts on growers' revenue, on crop production performance, and most importantly, on plant health and quality.



HIGH-TORQUE AUTOMATIC CLUTCH

Weasler Engineering
West Bend, Wisconsin, USA
www.weasler.com

Weasler Engineering's High-Torque Automatic Clutch is designed for high-torque and high-inertia applications, such as large square balers, combines, and self-propelled forage harvesters. The unpredictable nature of the crops and undesirable materials encountered while operating such equipment can create a need to limit the power supplied to the implement. After a torque overload occurs, this clutch automatically reconnects at low speed, improving crop feeding characteristics moments before full reconnect, which allows the operator to remain seated with minimal interruption of the task. Designing reconnect characteristics into the clutch allows long life while rotating at speeds up to 1500 rpm. This convenient, maintenance-free protection comes with maximum mounting flexibility to flywheels, sprockets, and more, giving machine designers optimal flexibility.



Prototype Grade IHB®
2014



IHB® Granules
2016



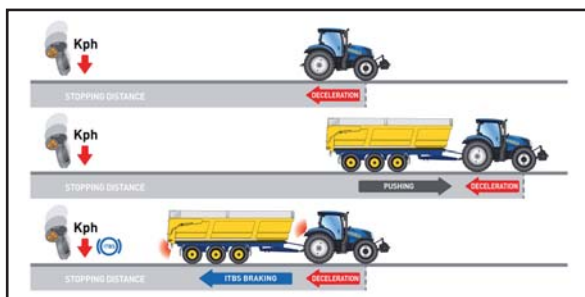
IHB® Microspheres
2017

IHB TECHNOLOGY

IHB Technologies, Inc.
Minneapolis, Minnesota, USA
www.ihbtech.com



The patented IHB (for "Infused High BTU") formula is available to biofuel producers who seek to advance the densification of biowaste. This granular product is blended with preprocessed biowaste materials. During high-temperature densification, the IHB granules liquefy and permeate the compacting biowaste. The resulting solid fuel delivers a dramatic increase in energy output, a significant increase in the rate of combustion, and safe emissions. The use of renewable biowaste for bioenergy production is limited by challenges with product density, high moisture content, low energy content, and the release of toxins. IHB overcomes these challenges by fusing a high-value formula into pellets, cubes, or briquettes, resulting in a strong solid that is highly resistant to moisture and biodegradation.



INTELLIGENT TRAILER BRAKE SYSTEM

New Holland Agriculture
New Holland, Pennsylvania, USA
<http://agriculture.newholland.com>

When a tractor and trailer's speed is reduced by just the transmission and engine braking alone, the momentum of the trailer pushes against the tractor. This pushing force can cause instability that increases the risk of jack knifing, especially on steep gradients or low-friction surfaces such as icy roads or grassland. The Intelligent Trailer Braking System senses the reduction in the tractor's speed and calculates the deceleration force using a torque sensor in the transmission. An electronically controlled pneumatic brake valve automatically applies the trailer brakes to reduce the trailer's speed at the same rate as the tractor, greatly improving its stability and avoiding the risk of jack knifing. No modifications are required to the trailed equipment.



INTELLIMIX™ ADVANCED MIXER CONTROL SYSTEM

Kuhn North America, Inc.
Brodhead, Wisconsin, USA
www.KuhnNorthAmerica.com

The IntelliMix™ Advanced Mixer Control System includes the first continuously variable transmission (CVT) available on a total mixed ration (TMR) mixer. The IntelliMix™ reduces mixing and feedout time, saves fuel and labor, and produces a thorough, consistent mix every load. This ISOBUS-compatible system automatically transitions between multiple auger speed setpoints throughout the mixing and feeding cycles, giving farm managers full control over the auger speed to provide the best mix quality without being limited to predetermined gear ratios. The IntelliMix™ CVT offers mechanical advantages never seen before on a TMR mixer. Tractor input speed can be reduced while independently maintaining auger speed. This provides fuel savings and allows a smaller tractor to be used with a larger mixer.



INTELLISENSE™

CNH Industrial Belgium N.V.
Zedelgem, Belgium
www.newholland.com

IntelliSense™ is a self-learning and pro-active automation system for New Holland CR Series combines that acts faster and is more stable than any other automation system on the market today. With industry-first cleaning shoe load sensing, next-generation Grain Cam™, and electrically adjusted rotor vanes, IntelliSense™ makes corrective adjustments before overloads or losses can occur. The operator can choose strategies ranging from maximum throughput to best grain quality, while always optimizing power efficiency. IntelliSense™ continuously and automatically optimizes the threshing, separation, and cleaning shoe settings to reduce grain loss, increase grain quality, and reduce fuel consumption. The system continuously seeks to increase productivity, within the loss limits set by the operator. The simple user interface allows novice operators to manage the harvest like a pro.

INTERMEDIATE SUMP GATE WARNING SYSTEM FOR GRAIN BINS

Sukup Manufacturing Company
Sheffield, Iowa, USA
www.sukup.com

The Intermediate Sump Gate Warning System for Grain Bins shuts off the unload system and warns the grain bin operator if an intermediate sump gate is open when it shouldn't be. This patent-pending warning system is designed to protect against off-center unloading, which is a top cause of failure in large grain bins. It can occur when intermediate sumps are opened before grain has stopped flowing through the center sump. Off-center unloading puts excessive downward pressure on the bin sidewalls and can lead to buckling or catastrophic failure. If an



intermediate sump is opened prematurely, the warning system shuts off the unload system and alerts the operator with a horn, voice, and/or flashing lights. Text-message warnings are optional.

JOHN DEERE TRACKS

John Deere
Moline, Illinois, USA
www.deere.com

The all-new John Deere Tracks offers superior transport speed, ground following, and flotation. A suspended dual-pivot design, tandem pivots, and lateral mid-roller oscillation provide improved ground following, and variable-rate damping adjusts the suspension as the machine weight changes during harvest. This superior ride quality was achieved with only one cylinder, compared to multiple cylinders on other track systems. The final drive gear case is integrated into the track undercarriage, reducing the stress on the final drives. Maintenance is reduced with oil baths and specialized bushings instead of grease joints. For North America, widths of 30 and 36 inches are offered, and customers still have the option to change between tracks and tires with the new track design.



KMC 5610 STALK SHREDDER PULLER

Kelley Manufacturing Company
Tifton, Georgia, USA
www.kelleymfg.com

The KMC 5610 Stalk Shredder Puller is a residue management tool that completely destroys stalks. With superior shredding and pulling capabilities, the KMC 5610 Stalk Shredder Puller performs multiple operations in a single pass. Marketed as a high-speed six-row machine, the KMC 5610 Stalk Shredder Puller has the additional ability to incorporate cover crops and remove the primary food source of pests, such as nematodes and boll weevils. The working speed is 6 to 10 mph, which can cover 12 to 20 acres per hour. Maintenance intervals have been minimized by using maintenance-free pivot bushings, self-adjusting pulling discs, and durable rotor bearings. Spring-loaded rear rolling baskets help dislodge roots from the soil and enhance the ability to incorporate cover crops.



MERGE MAXX® MM 1300 HAY MERGER

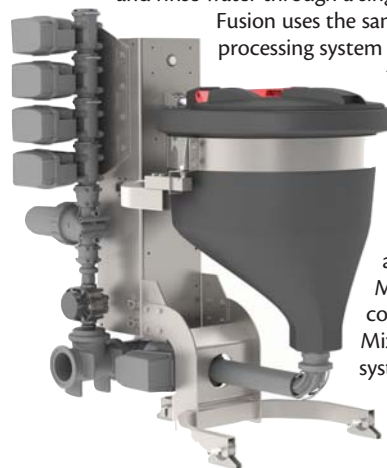
Kuhn North America
Brodhead, Wisconsin, USA
www.kuhn-usa.com

The Kuhn Merge Maxx® MM 1300 hay merger is the largest merger on the market, with 42 feet of pickup in a single pass. The wide working width maximizes operating efficiency and is coupled with durability and simplicity of operation. Designed for commercial operations, the MM 1300 incorporates six tine-bar cam pickups, along with exclusive tine arm wear guards and anti-wrapping discs. The floating windguard ensures smooth and even windrows to maximize forage harvester efficiency, while the crop netting improves leaf retention. Simple and durable mechanical flotation on each head eliminates the need to engage float via the tractor's hydraulics. ISOBUS compatibility is standard and improves operator ergonomics and reduces fatigue, as well as eliminating the need for additional monitors in ISOBUS-compatible tractors.

MIXMATE FUSION

Praxidyn
Oakland, Iowa, USA
www.praxidyn.com

Mixmate Fusion measures flow for automated mixing of bulk products and includes a specially designed inductor that measures by weight, all in one compact unit. The inductor includes a high flow rate rinsing system for better handling of dry products, and the new software and electronics support a valve manifold that automatically routes multiple bulk inputs and rinse water through a single flowmeter. Mixmate



Fusion uses the same patent-pending processing system as the original Mixmate to drain, measure, rinse, record, and reconcile the data in about 12 seconds. The scale and flowmeter are precalibrated, and no additional calibrations are needed in the field. Mixmate Fusion is compatible with existing Mixmate components for system expansion through CANBUS connections.

OUTCROSS 9060

The Toro Company
Bloomington, Minnesota, USA
www.toro.com

The Outcross 9060 combines the features of a utility tractor, such as a rear PTO, three-point hitch, and front-end loader, with the usability of a heavy-duty vehicle, expanding the productivity and safety of operation in turf applications. Featuring programmable operation of attachments, such as three-point lift height and PTO speed, the Outcross 9060 accommodates lesser-skilled operators. Full-time four-wheel steering and four-wheel drive combined with a proprietary traction control system ensure turf-friendliness while carrying out a myriad of tasks. A rear bed (with an optional high-capacity bed), side-by-side seating, cruise control, transport speeds above 20 mph, and an optional remote control kit that provides operation of the three-point hitch, traction, and PTO from the rear of the machine maximize the productivity of the Outcross 9060.



OXBO 6170 PEA HARVESTER

Oxbo International Corporation
Byron, New York, USA
www.oxbocorp.com

The Oxbo 6170 Pea Harvester advances the art of harvesting peas and lima beans by using a new threshing auger beater with independent speed control and an automated load control system. The result is optimized ground speed and crop flow, increasing capacity by 5% in weedy and hilly conditions and increasing ground speed by up to 80% in lima beans. The 6170 features a mechanical 6WD option, increasing road speed by 25%, increasing braking capacity by 300%, and enhancing traction in the field with gear-driven bogies and a mechanical differential lock, which were not available on previous hydraulic wheel motor drive systems. The new Tier 4F engine increases power by 12% and reduces fuel consumption by over 20%.



POWERFLEX TRAX WITH TERRAFORM SUSPENSION™

ATI Inc.
Mt. Vernon, Indiana, USA
www.ati-tracks.com

PowerFlex Trax with TerraForm Suspension™ is a fully suspended track system for combines. This new design maintains a constant load distribution between the axles independent of the vertical load and allows each idler axle and bogie wheel to follow the ground contours. This reduces machine vibration for less downtime, lower operator fatigue, and greater productivity, with enhanced field speeds and smooth travel speeds up to 25 mph. The smooth ride provides a stable platform for combine headers, reducing grain losses. Maintenance is minimized, and transparent hub caps allow quick checks of hub oil levels. The belts are a heavy-duty design with wider lugs for longer life. The 30% larger footprint enhances flotation in soft soils and reduces compaction.



PRECISION DISK™ 500DS

Case IH
Racine, Wisconsin, USA
www.caseih.com

The Case IH Precision Disk™ 500DS is a precision disk drill that provides ideal seed and fertilizer placement in one pass. Seed is placed 1 inch to the side and 1 inch above the fertilizer row with the Precision Placement Knife™. This fixed relationship provides excellent fertilizer efficiency while maintaining safe separation to reduce the risk of seed burning even while turning. The 500DS is offered with 10 inch spacing on four working widths: 30, 40, 50, and 60 feet. This drill also has superior ground following due to the shorter wheelbase and parallel-link row units. The shorter wheelbase is accomplished with a two-rank design, rather than three ranks, and the new parallel-link row units allow travel of 8.5 inches up and 11.5 inches down.



PRECISION SHANK DRILL

AGCO-Amity JV, LLC
Wahpeton, North Dakota, USA
www.amitytech.com/air-seeding-equipment

The Amity Precision Shank Drill (PSD) blends the best features of the original concord® air seeder with modern technology, with no daily maintenance needed. The row units incorporate multiple features that make this 61-foot PSD perform precisely, even at higher operating speeds. The independent-link row units provide precise depth control, exceptional ground following, smoother field finish, and better packer wheel performance, which all lead to better seed placement. Each row unit uses individual rippled coulters with active hydraulic down pressure to slice trash and fracture the soil ahead of the opener to keep residue flowing and minimize soil blowout. Independent closing discs capture the soil displaced by the opener so that it can be properly packed over the seed.



RBMPRO 2000™ SELF-LOADING WRAPPED SILAGE BALE MOVER

Groupe Anderson Inc.
Chesterville, Québec, Canada
<https://grpanderson.com>

The RBMPRO 2000™ self-loading bale carrier picks up, carries, and unloads wrapped round bales. The RBMPRO 2000™ is fully automatic and features a loading arm, an in-motion loading system, and a rotating grabber. Wrapped bales can be grabbed at a travel speed of 3 kph without damaging the plastic. Bales can be collected vertically or horizontally when traveling the same path as the baler-wrapper. The RBMPRO 2000™ also features an adjustable roller bed platform that can carry up to 20 bales from 4x4 feet to 5x5 feet, and rear hydraulic stoppers that allow unloading of bales on their flat ends or on their sides. The RBMPRO 2000™ is a time-efficient and cost-effective way of transporting wrapped bales.



REAL-TIME IN-LINE INCLINED FLOWMETER (RIIF)

FloMetrix, Inc.
Ames, Iowa, USA
www.FloMetrix.com

The Real-time In-line Inclined Flowmeter (RIIF) is a proprietary solution for continuously measuring the flow rate and total flow of bulk materials when the materials flow on an incline, such as in a pipe, tube, or conduit. Storage and handling of bulk materials such as seed, grain, and fertilizer requires accurate and continuous flow sensing for process control, automation, and inventory management. Currently, sensing technologies exist for vertical flow, but there is no sensor for measuring non-vertical flows without changing the operating geometry of the system, interrupting the flow, or damaging the material. The RIIF flowmeter closes this technology gap. FloMetrix inclined flowmeters are affordable, safe, compact for installation in tight places, and do not damage bulk materials.



**RECON
SPREADSENSE®**
Intelligent Agricultural
Solutions
Fargo, North Dakota, USA
www.intelligentag.com

Recon SpreadSense® is the industry's first blockage monitor for boom-type dry fertilizer applicators. Using patented technology originally developed for air seeders, acoustic sensors are easily installed onto each deflector, where they listen to the material flow and send sound pulses through auditory tubes, similar to a stethoscope. These acoustic signals are collected by an electronic control unit (ECU), which transmits the information to an iPad in the cab. If a blockage occurs anywhere in the system, the operator receives an alert. Eliminating the need to visually detect flow issues allows operators to extend their run time in low-light conditions and increase their productivity. For commercial applicators, Recon SpreadSense® helps ensure high-quality applications across their operations.

SAUNA FOOD WASTE NUTRITION CONVERSION SYSTEM

Treasure8
San Francisco, California, USA
www.treasure8.com

The SAUNA Food Waste Nutrition Conversion System converts imperfect produce or food processing leftovers into useful products. Invented by the USDA and commercialized by Treasure8, SAUNA uses low-energy drying to trap the

micronutrients, flavors, and colors of fruits, vegetables, and tubers, shrinking them into nutritionally dense foods within an hour, while using up to 73% less energy than frying and 83% less energy than freeze-drying. SAUNA allows growers, processors, and packaged goods companies to minimize their



costs and carbon footprint while creating high-quality products. This eco-friendly technology has uses beyond turning excess or "ugly" produce into value-added products. In developing countries that lack cold-chain distribution, SAUNA can be deployed to capture nutritious food before it goes bad.

SCORPION 350 HARVESTER

Dion-Ag Inc.
Boisbriand, Québec, Canada
www.dion-ag.com

The Scorpion 350 pull-type forage harvester (PTFH) incorporates technology previously found only on self-propelled forage harvesters. It is the only PTFH on the market with full ISOBUS controls, which integrate an easy-to-use graphical display, assignable auxiliary functions, and advanced features such as a volume counter and load monitoring. With a 350 hp PTO rating, it maximizes profitability by exploiting technology offered on modern high-horsepower tractors. The hydraulic feedroll drive, powered by the tractor's load-sensing power beyond ports, allows an infinitely adjustable length of cut and smooth starts. An industry-unique ultra-fast solenoid valve ensures reliable emergency stops and metal detection. The Scorpion 350 harvester shares the efficient straight-through

design, simplified sharpening, and optional STINGER side-loading spout offered on other Scorpion models.





SPOTON® INVERSION TESTER

Innoquest, Inc.
Woodstock, Illinois, USA
www.innoquestinc.com

The SpotOn® Inversion Tester is a handheld meter for quantifying the surface-level thermal inversions that affect herbicide and pesticide application. The volatility of dicamba-based herbicides, along with the high sensitivity of many plants to low levels of this chemical, has created the need for this product, given the role that thermal inversions play in off-target application damage. The SpotOn® Inversion Tester features a two-button user interface and a backlit LCD for use in low light conditions. Simply waving the high-accuracy shielded temperature sensor at 1- and 3-meter heights provides an inversion indication in less than 3 minutes. The rugged rainproof design folds for easy transport and storage in the sprayer cab for in-field measurements prior to application.



SWATHPRO™ AERIAL APPLICATION SYSTEM

Capstan AG
Topeka, Kansas, USA
capstanag.com/aviation/

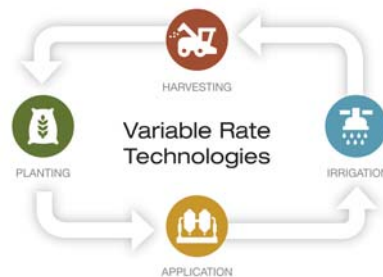
SwathPro™ is a precision spray system for aerial application. It provides unlimited nozzle and boom configurations to address spraying conditions such as wind speed and direction, adjacent crops and non-target areas, and aircraft speed with the push of a button, while maintaining the desired spray pressure and application rate. Safety is improved by significantly reducing the exposure of the pilot and tender to chemicals that deposit on the nozzle bodies, and efficiency is improved by saving the time needed for nozzle or boom changes between jobs. Other features include the ability to proactively limit drift potential, and an aerodynamic boom that minimizes drag. SwathPro™ allows pilots to provide the best possible spray application every time they take off.



TERRAGATOR® C SERIES HIGH-FLOTATION APPLICATOR

AGCO Corporation
Duluth, Georgia, USA
www.challenger-ag.us

TerraGator® C Series high-flotation applicators are designed for the narrow application windows driven by tightening agronomic requirements. This is the first high-flotation application equipment with operator controls closely aligned with row-crop application equipment, so operators can move between machines with little or no learning curve. On the three highest horsepower models, efficient control software for the continuously variable transmission (CVT) delivers 10% more power to the ground, while the touch screen interface controls cruise speed, shuttle speed, and acceleration/deceleration, so the operator can set the machine to perform to specific preferences. Agronomic enhancements for liquid and dry application focus on precise placement with finer section control, as well as maximum crop coverage and minimum environmental impact.



VARIABLE RATE HARVESTING

CLAAS of America Inc.
Omaha, Nebraska, USA
www.claas.com

Variable Rate Harvesting (VRH) is one of the Variable Rate Technologies that combine precision sensor technology with autonomous machine control, currently available on all CLAAS LEXION combines and JAGUAR forage harvesters, to automatically optimize a harvester's performance according to changing conditions of the soil, plants, grain, and humidity in the harvested field. VRH completes the VRT circle of planting, application, irrigation, and harvesting. VRH will help farmers embrace the variability in their fields with zone management to maximize productivity in areas that have the greatest yield potential. VRH can maximize performance based on crop conditions, crop volume, and field topography. It reduces labor, fuel, and machine costs while improving throughput, grain retention, feed quality, and harvesting speed.



WR9900 SERIES WINDROWER CAB SUSPENSION

AGCO Corporation
Duluth, Georgia, USA
www.agcocorp.com

The OptiAir™ windrower cab suspension incorporates a four-post air suspension system for operator comfort and noise suppression. The OptiAir™ provides 40% less vibration, which is a significant improvement over other systems. Up until now, suspension systems on self-propelled windrowers have relied on either coil springs that compromise the ride comfort or passive airbag systems that require manual adjustment. This system uses self-leveling airbags on all four corners of the cab that are automatically adjusted by the on-board air compressor and pneumatic system. This combines the superior comfort of pneumatic suspension with the maintenance-free aspect of coil springs. The OptiAir™ automatically compensates for weight variations, such as when a second person is in the cab.



XTRACTOR - SKID STEER AND TRACTOR TREE-PULLING ATTACHMENTS

Skid Steer Multiple Tool Bar LP
San Marcos, Texas, USA
<http://bigskidsteer.com>

XTractor is a tree-pulling attachment for all skid steers and tractor loaders with quick-attach systems. It pulls trees by their roots, including trees with extensive root systems in difficult soils. It outperforms other tree pullers that jerk trees by their trunks, leaving holes in ground, or that cut the roots, leaving them to resprout. XTractor is the only attachment that uses an integrated fulcrum to gain a 3:1 mechanical advantage to extract trees. There is minimum disturbance to the vegetation and topsoil. With its integrated fulcrum, wrap-around steel construction, and open-beam design, XTractor can pull larger trees faster with better vision, and is stronger and less costly to manufacture.

YPC News & Notes

The 2019 Agricultural Equipment Technology Conference (AETC) is fast approaching. There is still time to register and join many other ASABE members at the Omni Louisville Hotel, February 11-13, to learn about new developments, emerging technologies, and standards work in the agricultural equipment industry. YPC members save \$170 on conference registration, while students save almost \$400!

Based on the number of registered attendees, the annual AETC is one of the most well attended conferences sponsored by ASABE, with many personal and professional development opportunities, especially for students and young professionals. The conference consists of numerous CPD sessions, technical sessions, invited speakers, a student poster session, and networking events. A popular event each year is our student-industry mixer, traditionally held at a local bowling alley. This is a fantastic opportunity for students and YPs to meet professionals from industry, government, and academia in a casual environment. Plus the bowling is free, and we've got pizza for dinner—a guaranteed strike!

This year, members of the AETC Planning Committee are organizing the first of a series of professional development sessions aimed specifically at students as well as early- and mid-career professionals. The overall theme will be “Exploring New Dimensions in your Career,” or, put another way, “What You Didn't Have Time to Learn in School.” Given the breadth and technical nature of engineering degree programs, many career-related topics are not able to be covered. An understanding of these topics, such as establishing objectives and evaluating performance, developing interpersonal skills and relationships, and handling finances, can have a significant impact on career satisfaction and long-term success.

The focus of the 2019 session will be “Investigating Your Career in Relation to Product Safety, Standards, and Conformance.” The speakers will represent industry and academia, with a wide range of experience in their technical fields and in standards development. The panelists will deliver firsthand accounts of how they integrated safety and standards into the development of new products and processes.

For more information, visit the AETC webpage: <https://www.asabe.org/AETC2019>. We hope to see you in Louisville!

ASABE member and YPC Past Chair Shane Williams,
Kuhn North America, Brodhead, Wisconsin, USA,
shane.williams14@gmail.com.

ASABE Takes a Stand

There's no place for gender and sexual harassment at our meetings

Veronika Vazhnik

Professional society meetings are a great place to share the passion for your work. Unfortunately, society meetings can create an atmosphere for a different type of passion—the type that makes some society members feel unwelcome. Yes, you guessed correctly, this short feature is about sexual and gender harassment—modern plagues that can ruin lives and ravage societies.

The #metoo movement has highlighted how widespread predatory behavior is. Even though the outcry has been most prominent in show business and politics, science and engineering are no different. Just consider these statistics: 43% of female graduate students at a large land-grant university reported experiencing sexual harassment from faculty or staff, and almost 60% of female faculty and staff in academia reported having been harassed. These statistics and others are documented in the 2018 report “Sexual Harassment of Women: Climate, Culture, and Consequences in Academic Sciences, Engineering, and Medicine” by the National Academies of Sciences, Engineering, and Medicine. Similarly, more than half of female members of the National Society of Professional Engineers have reported experiencing sexual harassment at work.

The National Academies report describes several factors that make science and engineering particularly prone to harassment: a strict professional hierarchy, isolated fieldwork, and historically male-dominated degree programs and disciplines. ASABE and its members face all of these risk factors, despite many proactive changes in our Society in recent years. The strict hierarchy and isolated fieldwork are difficult to avoid, but the demographics are changing, with many more women enrolling in graduate programs and working in engineering positions. Moreover, our Society's leadership includes more women, including ASABE Presidents, Trustees, and female leaders at every level. ASABE has also been making progress in dealing with sexual harassment. In 2016, the Board of Trustees adopted a policy on harassment and safety, which is posted on the ASABE website (<https://asabe.org/Events/Harassment-Policy>).

Because of these and other forward-thinking actions by our Society, you might be thinking: “Other professional societies might have problems with sexual harassment and discrimination, but not ASABE—we're so progressive!”



Unfortunately, ASABE has not escaped harassment and the related behavior patterns that are too common in the rest of the professional world. Sadly, at our 2018 Annual International Meeting, we heard comments that assumed that all women in the room were engineers' wives, not engineers themselves. Even more disturbing, at the same meeting, a member of the Young Professionals Community was groped by a more senior member. We can only guess about incidents that were not reported in previous years. These examples show us that, even though our Society is taking action, more work is needed to welcome a more diverse membership.

“Achieving gender equality requires more than just imposing punishment for misconduct. We must also value each member's contribution to our Society.”

What can ASABE do to prevent repetition of last year's incidents? There are no established guidelines, which is why ASABE leadership and staff are forming a consortium of professional societies led by the Association for the Advancement of Science, the National Academies, the American Geophysical Union, and the EducationCounsel. This consortium will develop customizable guidelines, frameworks, and toolkits for professional societies to use in addressing harassment.

One of the most critical steps that a professional society can take is to change its internal culture. Part of that change is educating society members about what harassment is and what to do when they see it or experience it. That's why ASABE's harassment policy has been prominently displayed at all ASABE meeting venues since September 2018. Some organizations go even further in changing their culture. For example, as of October 2018, the Association for the Advancement of Science will revoke the fellowship of an individual who commits misconduct, which now includes harassment, and the American Geophysical Union has pledged to investigate harassment cases involving its members, independent of whether the incident happened at an AGU event or elsewhere.

Achieving gender equality requires more than just imposing punishment for misconduct. We must also value each member's contribution to our Society. The actions by ASABE and other organizations to prevent harassment should remind us to treat everyone we meet, in work and in life, as a whole person, with a unique identity, personality, and talent. We must learn to recognize and banish words and actions that exploit or objectify individuals, whether by making offensive comments about their gender or by touching them without their consent. We must learn to treat each person as we would want to be treated—as someone who is worth listening to, learning from, and working with. Establishing a culture of respect will take some effort from each of us, not just while attending Society meetings but whenever we interact with students, colleagues, and co-workers. For the future of ASABE, help us build a more inclusive, more creative, and more productive community of professionals.

If you have experienced sexual or gender harassment during an ASABE event, or if you have witnessed harassment, please contact the ASABE or YPC leadership to resolve the situation. Your confidentiality will be respected, and we will take your concerns very seriously, because we are devoted to making you feel safe, valued, and welcome.

ASABE member and YPC grad student representative

Veronika Vazhnik, Doctoral Student in BioRenewable Systems, Department of Agricultural and Biological Engineering, Pennsylvania State University, University Park, USA, and Graduate Fellow, Idaho National Laboratory, Idaho Falls, USA, vzv6@psu.edu.

Contributing to this article: **ASABE Fellow and President-Elect**

Sue E. Nokes, P.E., Professor and Chair, Department of Biosystems and Agricultural Engineering, University of Kentucky, Lexington, USA, snokes@uky.edu.

The Ethical Dilemma Behind Antibiotics in Animal Feed

LeeAnn Johnston

Editor's Note: ASABE member **LeeAnn Johnston**, a senior at Auburn University, took first place in the 2018 Ag and Bio Ethics Essay Competition by submitting "an original work of up to 1,500 words on an ethics topic impacting the practice of professions related to agricultural and biological engineering, systems, or technology." Open to undergraduate and graduate student members of ASABE and IBE, second place went to **ASABE member Kayla Kassa** of North Carolina State University for "One Design Does Not Fit All: Putting Ethics at the Top of the Bank," and third place was awarded to **ASABE member Cami Shands** of Auburn University for "Ethical Issues in Food Manufacturing: The Melamine Milk Scandal." Congratulations to our 2018 finalists, who presented their essays at the 2018 Annual International Meeting in Detroit, Michigan.



Throughout history, the desire to maximize food production has been one of the driving forces in global society. As scientific discoveries and engineering achievements create newer, more efficient agricultural processes for the modern world, questions begin to arise

among academic and non-academic minds alike. Intentions are called into question, and potentially negative health consequences of these discoveries and their application are debated at length. This paper seeks to define some pros and cons involved with adding antibiotics to animal feed as well as discuss the ethical issues surrounding such usage.

First and foremost, there are benefits to adding antibiotics to food given to animals that will become food for people. The most obvious benefits are the treatment of disease in sick livestock as well as the prevention of disease in otherwise healthy individuals ("Effects...Feed"). The addition of antibiotics to feed in the case of a healthy animal prevents progression of diseases that would make them too sickly to slaughter for production purposes. Not only does this benefit the animal's health, but it also increases yield for the farmer or company. A second benefit is that added antibiotics aid some animals' digestion processes (Hakim 2018). In the case of cattle, their natural diet consists of mainly grass, so there are complications involved with digesting the grain-based feed provided at a feedlot (Hakim 2018). Antibiotics help to mitigate some of the common side effects, such as liver abscesses (Hakim 2018). Another benefit of antibiotics in feed is the increased growth rate of the animal ("Effects...Feed"). While this does not necessarily affect the health of the animal, the increased growth rate increases yield for the pro-

ducer and could theoretically cut cost to the consumer (“Effects...Feed”). The benefits to the health of both the animal and the consumer, in addition to the production yield for the farmer, are all positive effects of adding antibiotics to animal feed.

There are, however, quite a few negative effects associated with the abundant use of antibiotics in animal feed. Perhaps the most detrimental effect of over-applying antibiotics is the potential to create bacteria dangerously resistant to the antibiotics (Slonczewski & Foster p. 1132). Bacteria have a relatively short lifespan as compared to that of a cow, thus several bacterial generations can be cycled through in the lifetime of the mammal. This quick reproduction time can allow a pathogenic strain of bacteria to evolve in just the right manner to become resistant to the antibiotics being used against it. Another likely scenario is that a non-pathogenic strain of bacteria could develop a resistance and then through various methods of gene transfer pass the resistance gene to the pathogenic strain (Slonczewski & Foster p. 1131). Through either method, a deadly strain of bacteria could develop out of the overuse of such antibiotics. Additionally, such bacteria may not affect the cow, chicken, or pig it grows in, but could be passed to the consumer. Such a sequence of events could cause an epidemic because once a bacteria is resistant to the antibiotic commonly used against it, its treatment becomes difficult and allows the resistance to spread (“Combating...Resistance”). This issue presents another negative consequence of antibiotic overuse: the necessity of discovering or synthesizing a new, effective antibiotic. Because the original antibiotic becomes effectively useless against a resistant strain, as in the case of penicillin (“Addicted...Facts”), scientists have to take a different approach to search for something within the new strain that can be targeted (Slonczewski & Foster p. 1134). This process takes time and uses resources that may have not been necessary had the overexposure to antibiotics not occurred.

After defining some pros and cons, the ethics behind the decision to use or not use antibiotics must be considered. On the anti-antibiotic side, the decision to only use antibiotics when livestock are actively sick or otherwise immunocompromised seems to be the most ethical decision because it decreases the risk of resistant genes being passed to pathogens. This leads to increased health in the livestock and the human population that consumes them and therefore is the most ethical approach from that point of view. On the pro-antibiotic side, such abundant use of antibiotics serves to prevent contraction of disease and increase yield, therefore producing more food. The problem seems to be very cut and dry, and it is the opinion of some microbiologists that antibiotics should not be used as much as they currently are in practice (Slonczewski & Foster p. 1131). The issue can get to be less black and white, however, when the wealth of the communities raising livestock are brought into the discussion. For

instance, is it ethical to demand that a small country in the developing world not use antibiotics on the minimal amount of cattle its farmers rely on? Is it ethical for them to be more concerned with production yield than the potential for deadly microbes to develop? Opinions vary, but the utilitarian approach of achieving “the greatest good for the greatest number” (“Utilitarianism”) may not be the answer, considering the vastly different motives of a first world country looking to supply fast food restaurants with cheap beef and the local farmer trying to feed his family and fellow villagers. Instead, it might be best to consider what is best for the people immediately affected by the livestock in question. Using this frame of mind, it would be ethical to require commercial companies to limit antibiotic usage to only the sickly animals. At the same time, it would also be ethical to allow farmers of small villages to use antibiotics to increase food production. With this line of thinking, the decision appears to be that antibiotics should not be used commercially in animal feed, but should not be refused in areas where food is scarce.

To conclude, several pros and cons surround the usage of excess antibiotics in animal feed. While there are differing opinions on whether or not such usage is ethical, the best approach may not be to search for one all-encompassing answer. Even so, if one definitive answer is reached, the realization that exceptions to the rule exist must be understood.

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ASABE Foundation Work in Focus

The John C. Nye Graduate Fellowship Fund

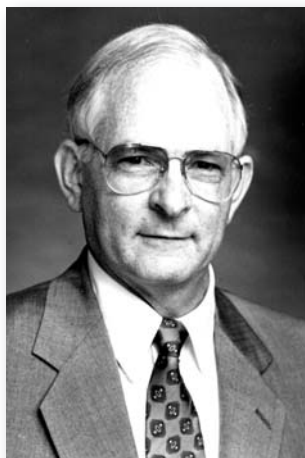
Dan Thomas, P.E.

The John C. Nye Graduate Fellowship Fund was established in 1999, dedicated to expanding the diversity of our Society. It was designed to encourage participation of underrepresented minority graduate students in ASABE and to aid minorities pursuing graduate degrees in agricultural engineering.

The idea behind the fund remained noble and appropriate—to grow diversity in our Society. Unfortunately, not strenuously championed, the fund languished well below an endowment level for many years. However, because of generous donations from John's widow Gloria, and an outreach effort to those who knew and respected John, we are thrilled to report that the fund is now endowed and will be awarded for the first time in 2019.

John Nye was born in 1945 and grew up on a Kansas wheat farm. He attended Kansas State University (BS) and then Purdue University (MS and PhD), where he joined the faculty in 1971. In 1984, he relocated to serve as head of the Department of Agricultural Engineering at Louisiana State University, and he relocated again in 1991 to become Dean of the College of Agriculture and Natural Resources at the University of Delaware. After a decade in that position, John accepted the positions of Director of the Delaware Agricultural Experiment Station and Director of the Delaware Cooperative Extensive Service, where he was employed at the time of his sudden and unexpected death of a brain aneurysm in 2002.

John's list of professional accomplishments is long. However, he considered his greatest achievements to be those forged from one-on-one relationships, where he could see the



**ASABE Fellow John C. Nye,
1945-2002**

direct difference he made in the lives of others. He encouraged everyone he knew to accomplish great things.

We are thankful for all those who stepped up and contributed to the John C. Nye Graduate Fellowship Fund to provide fellowships for minority students pursuing PhDs in agricultural engineering. We would not have reached our endowment goal without the donations from colleagues, friends, and the Nye family, especially Gloria Nye. We believe no better legacy exists for John than to have fellowships awarded each year in his name. Fran Fevier, a long-time friend of the Nyes, eloquently summed up how many felt about John and the impact he had on hundreds of lives:

"Dr. John Nye was a rare and beautiful human being. He was an idealist able to translate his ideas into practical actions. He looked for the good and the promise in people, especially in his students. Whenever he glimpsed promise, John went all out to support and encourage its development."

If you have an interest in supporting the ASABE Foundation and the work it does, please contact Mark Crossley, ASABE's Director of Development, at 269-932-7002 or crossley@asabe.org to learn the many ways you can help.

ASABE Fellow Dan Thomas, P.E., Professor, Department of Biosystems and Agricultural Engineering, Oklahoma State University, Stillwater, USA, daniel.thomas@okstate.edu.

This is one in a series of articles from the Foundation Development Committee.

ASABE Fellow Sylvia Schonauer, P.E., Foundation Trustee and Development Committee Chair, Principal Engineer (retired), W.K. Kellogg Institute, Bellaire, Mich., USA, sylvias@valkyrie.net.



Honoring the Newly Elected

At the 2018 Annual International Meeting in Detroit, thirteen new ASABE Fellows were recognized. Continuing from the previous issue of *Resource*, and in the next issue, we're shining the spotlight on these recent honorees.

Fellows must have a minimum of 20 years of active practice in, or related to, the profession of engineering, the teaching of engineering, or the teaching of an engineering-related curriculum. The designation Fellow has honorary status, to which members may be elected but may not apply.

As the ASABE Constitution states, Fellows are "of unusual professional distinction, with outstanding and extraordinary qualifications and experience in, or related to, the field of agricultural, food, or biological engineering." Election to Fellow is one of the highest distinctions an ASABE member can achieve, and *Resource* looks forward to acquainting you with more of ASABE's best and brightest.



Michael Boyette, P.E., Philip Morris Professor, Department of Biological and Agricultural Engineering, North Carolina State University, Raleigh, is honored for his practical application of agricultural and biological engineering to the postharvest handling of fresh fruits and vegetables.

Boyette has conducted comprehensive research in sweet potato storage, which led to his development of the negative horizontal ventilation system, significantly improving storage of the crop. As a result, sweet potatoes can now be stored and sold year-round, leading to tremendous economic advantage for producers. In North Carolina, sweet potato acreage has tripled since the early 1990s, and more than 95% of sweet potato storage in the U.S. uses negative horizontal ventilation systems. These systems are also used in sweet potato-producing regions around the world. Throughout his career, Boyette's pragmatic approach to research has led to effective solutions that work within the constraints common to postharvest processing—a limited season with short payback periods, difficult environments, and often a high potential for human error.

Pictured above: Mike explains sweet potato drying to a grower.



Dean Eisenhauer, P.E., Emeritus Professor, Department of Biological Systems Engineering, University of Nebraska-Lincoln, is honored for his broad and extraordinary contributions in teaching, extension, and research emphasizing engineering practices for improved water management in agriculture.

Prior to his retirement in 2015, Eisenhauer was a professor in UNL's Department of Biological Systems Engineering, where he taught courses in irrigation systems management, irrigation laboratory and field study, soil and water resources engineering, modeling of vadose zone hydrology, hydrologic modeling of small watersheds, and soil conservation and watershed management. In addition to his teaching responsibilities, Eisenhauer conducted research in agricultural hydrology and irrigation. His research in infiltration and irrigation led to practical improvements in furrow irrigation management. Eisenhauer also developed a course on subsurface flow and transport to address vadose and groundwater system challenges related to groundwater depletion.

Pictured above: Dean, far right, teaching a lab.

Clifford Fedler, P.E., Professor, Department of Civil, Environmental, and Construction Engineering, Texas Tech University, Lubbock, is honored for revolutionizing the design and use of wastewater land application systems, which has reduced costs and protected environmental conditions.



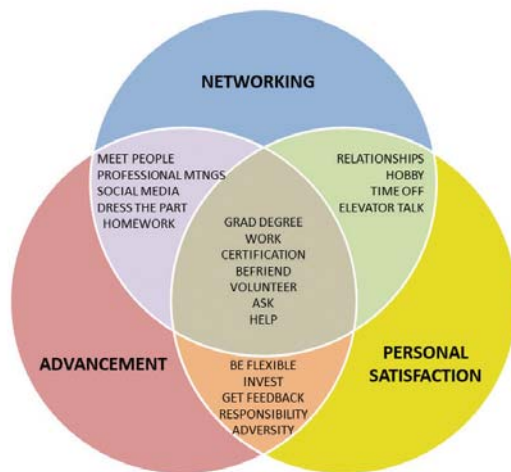
Fedler has made significant contributions to the field of wastewater technology, including the design of integrated facultative ponds, and he created a new approach to determining the water balance used to design land application systems. Fedler has conducted research on the flow of granular material by gravity through orifices, and this work eventually informed a portion of an ASABE standard. His analysis of irrigation application efficiency and the resultant leaching of nitrogen into groundwater has been adopted in Texas as a standard for designing on-site wastewater surface application systems. Fedler is also a prolific educator, developing programs used around the world. He has also raised endowment money for educating thousands of graduate students.

Pictured above: Clifford, far right, celebrates building his first wheelchair-accessible Habitat for Humanity house.



Achieving Balance in Your Early Career

Kendall DeJonge



Venn diagram showing the relationships among networking, advancement, and personal satisfaction. Note that the colors in the overlapping areas correspond to the colors of the related sections in the text.

Early Career Member

Undoubtedly, at some point early in your career, you will receive advice from those who have been there before. Often this advice can be helpful—in my mind, it is important to balance your ability to network and communicate with others, advance your responsibilities, and focus on self-preservation and personal satisfaction. Here are some specific things that I’ve learned over the years:

Meet people—Sounds cliché, but many opportunities come up through networking. Every job I’ve had can be attributed at least partially to someone helping me: a classmate, department head or instructor, alumnus of my university, people I met in past interviews, and mutual connections.

Attend professional meetings—It’s great for networking, gaining new ideas and perspectives, meeting up with old friends, fostering collaboration, and seeing new places. You might learn more having dinner or drinks with colleagues at a meeting like this than you would in a month at your office. Consider posters over presentations, especially if the meeting has short talks. Presentations seem to have more prestige, but a poster allows you to interact with people interested in the subject without being rushed to the next talk.

Be strategic with what you put on social media—Employers check the social media of potential employees. Luckily, I went to college in the era immediately prior to Facebook, so I have albums full of photos that are privately stored in my closet rather than publicly displayed on the web. However, lots of people now talk about the idea of “branding” yourself, an idea that is foreign to people my age and older, but is increasingly important for younger generations.

Dress the part—How you dress and present yourself has a lot to do with first impressions, substantiated or not. When you are fresh out of college, you probably look it. My first job out of school was an agricultural manufacturing sales job; when I grew a beard, I was treated like I was ten years older. Applicable to both men and women, dress appropriately for the occasion. On a field or farm visit, wear clothes and footwear that you expect to get dirty. At a professional dinner or meeting, wear clothes that you expect to keep clean. Remember that it is much easier to dress down than to dress up.

Do your homework—Whether for a job interview or in a staff meeting, if you have some background knowledge about the company or people you’re meeting with, it will give you a step up.

Be flexible—You may not get your dream job the first time around. Maintain a good network of people, and other opportunities will come up. Sometimes it takes doing something you don't like to find out what your real priorities and passions are.

Invest early—Start a Roth IRA, and put money in it. Even the smallest amount helps get you in the habit of investing, and you will thank yourself years later. If you can retire early, you will have more flexibility to pursue your passions.

Get feedback—Your annual reviews with supervisors, meetings with mentors, etc., are meant to assess your work, but they are also the best chance you have to receive honest feedback. Nobody likes to be told they have deficiencies, but in the end, it will make you a better worker and help your career. Find a mentor, formal or informal, who will be an advocate for you.

Earn the freedom of responsibility—The best employees that I supervise are those who do high-quality work with minimal supervision; however, this responsibility does not come immediately. Lead by example, volunteer for projects, and do a good job. Ask questions when appropriate. You will be much happier at your job if you are given freedom rather than being micromanaged, but most supervisors will require you to earn that privilege.

Be prepared to meet adversity—You will have a difficult boss, a colleague or coworker you can't stand, a professor who is difficult to deal with, or a rival. Probably all of them. Working through these issues will improve your career as you develop yourself, even though they are very frustrating at the time.

Maintain personal relationships—Surround yourself with people who are positive influences. Professional life can be stressful, and sometimes you'll need to talk with someone outside of work. This can be a spouse or significant other, family, or friends. Remember to return the favor and be supportive of those who support you.

Start a hobby—Outside of your professional life, having something useful or creative to focus on other than work can be a nice break and can give you more perspective when you need it.

Take time off—You will need time to recharge your batteries. Consider what the busy times are for your job, but don't let perceived limitations keep you from using your earned time off.

Have an elevator talk ready—Your work will not be fully understood by most people, but sometimes your most important conversations will involve explaining broad concepts in a simple matter. Try explaining your work or research in only a couple of sentences. It will make conversations easier with important people like administrators or politicians. Or your grandmother.

Consider a graduate degree—It shows advancement in your skill set, especially technical skills, research autonomy, project and timeline management, and writing. These abilities will all be valuable throughout your career. Many employers may support you in this endeavor, but make sure you are committed to this significant undertaking.

Work between your degrees—Many people go straight from undergrad to graduate school. Others may have different advice in this regard, but I worked in between each of my degrees and found it valuable to gain practical work experience before committing to a multi-year graduate program. Taking the time to gain focus is time well spent. The biggest downside is that your income goes through a roller coaster; going back to not making money is difficult.

Obtain certification—Get a professional license or other credentials in your field. You would rather have it and not need it than not have it and need it. These credentials represent your proficiency in job-related skills and look great on a résumé.

Befriend your administrative staff—They do a tremendous amount of work to help you succeed, and they are rarely recognized for it.

Volunteer but know when to say no—Early in your career, it's tempting to become involved in multiple organizations and multiple projects with multiple responsibilities. As your career progresses, you will get to a point where adding more to your plate will eventually take away from another commitment. It's better to do a few things well than a lot of things poorly. When you prioritize the things you really like to do, don't be afraid to say no when you're asked to do additional things.

Ask for opportunities—You don't get what you don't ask for. If you have an opportunity to be promoted or feel a raise is justified, ask for it! In nearly all cases, the worst thing they will say is no—and they may even be impressed that you asked.

Ask "What can I do to help"?—This very simple question shows that you are willing to help and that you care, without making suggestions on how things should be done. If they tell you no, at least you offered.

ASABE member Kendall DeJonge, Agricultural Engineer, USDA-ARS Water Management and Systems Research Unit, Fort Collins, Colorado, USA, kendall.dejonge@ars.usda.gov.

This article originally appeared in *CSA News* (February 2018) and is reprinted here with permission from the publisher.

Visual Challenge 8

VIEW FINDERS

IMAGES OF AGRICULTURAL AND BIOLOGICAL ENGINEERING

Engineers are proficient in science and technology, and they are good communicators as well. Although engineers traditionally express their work with words and numbers, each year *Resource* asks ASABE members and their colleagues to communicate with images—statements without words—to celebrate the visual aspects of agricultural and biological engineering. For our eighth year of the Visual Challenge, we are delighted to present selected images from the more than one hundred entries we received.

The beauty and meaning of your work, your research developments, and your Society's technical communities come to life in these images, showing those outside the ABE field: "This is what we do."

While the selection process was inevitably subjective, we hope these photos provide a glimpse into the variety of activities, workplaces, and surprises that an ABE career can offer.



ASABE member A. J. Both,
*Rutgers University, Department of Environmental Sciences,
New Brunswick, New Jersey, USA.*

MIMICKING THE SUN

Ceramic metal halide and incandescent lamps installed in the ceiling of a plant growth chamber. The spectral output and electrical efficiency are the main factors determining lamp choices.

LINED UP LIKE A MARCHING BAND

Greenhouse-grown poinsettias in August in preparation for the Christmas holiday. Note the different plant sizes (intended for different markets) and the regular plant spacing.



ASABE member Allison Graham,
*Engineering Group Lead, Engineer-in-
 Training, Vaderstad Industries Inc.,
 Langbank, Saskatchewan, Canada.*

FIELD DAY

At first glance, this photo appears to show a group of farmers getting ready to start the seeding rig for the day. In reality, it's a group of engineers and programmers out to test a new iPad app that controls the seeding rig. For anyone who thinks that the life of an engineer is sitting alone in the dark in front of a computer, think again.



ASABE Fellow and Past President Jim Dooley, P.E.,
Chief Technology Officer, Forest Concepts, LLC, Auburn, Washington, USA.

FEEDSTOCK AT REST

The angle of repose for biomass is an important indicator of flowability.



Photo by Jason Richards, submitted by ASABE member Erin Webb, Senior R&D Staff, Environmental Sciences Division, ORNL, Oak Ridge, Tennessee.

POPULAR POPLAR

Hybrid poplar logs in a greenhouse at Oak Ridge National Laboratory demonstrate the effect of genetic variability on plant development. The logs from different clones grew in the same plots and were harvested at the same time. ORNL researchers are using genomics to design biomass feedstocks with high yield and uniformity for biofuel and bio-product production.

ASABE member Erin Webb, P.E.,
Senior R&D Staff, Environmental Sciences Division,
Oak Ridge National Laboratory, Oak Ridge, Tennessee, USA.

ON A ROLL

This sorghum bale was part of a harvesting demonstration at the Genera Biomass Sorghum Field Day, where east Tennessee farmers were invited to learn about producing biomass sorghum. The standing sorghum plants in the background are 20 feet tall. Biomass sorghum grown for Genera will be used to produce fiber and compostable food packaging products.



ASABE member Brian McLaughlin,
Safety Psychographics LLC, Notre Dame, Indiana, USA.

AIRBORNE FERTILIZER APPLICATION

The spring of 2018 was long and wet, setting much of Michigan's farming way behind schedule. This delay shifted some fertilizer applications from ground-based to aerial platforms, which are more typically used for fungicide, pesticide, and herbicide spraying later in the season. In this photo, a specialized truck, equipped with a small bin and auger, is loading a plane with urea. Often, two planes tag-team the application duties, with one reloading while the other is in the air. When the fields are close together, the planes can come in seemingly non-stop, and the reloading process can resemble the pit area at the Indy 500, with the loaders and drivers working as a highly coordinated pit crew.

CRIMSON WAVES OF PLASTIC TUBING

In St. Joseph County, Michigan, 44% of the farmland is irrigated, mostly with center-pivot systems. This impressive figure amounts to 103,980 acres with irrigation. St. Joseph County is home to nearly 23% of all irrigated land in Michigan. Even more impressive is that this county contains more irrigated land than any other county east of the Mississippi River. The regional seed corn industry produces two million bags of seed corn a year, valued at more than \$192 million, which is used to plant more than six million acres of commercial corn. Specialty crops (seed corn, snap beans, potatoes, and pickles) could not be part of this agricultural economy if not for the abundant groundwater. In the background is a fertilizer spreader loaded with urea pellets, providing timely nutrition for the growing crop.





ASABE Fellow Gerald Rehkugler, P.E., *Professor Emeritus, Department of Biological and Environmental Engineering, Cornell University, Cortland, New York.*

WHEAT HARVEST WITH SELF-LEVELING COMBINE

My wife and I journeyed cross-country following a northerly route from New York to Washington State. As an ag engineer, I'm always aware of agricultural landscapes. Near Pendleton, Oregon, our motel was at the edge of a wheat field being harvested by a self-leveling combine. I could see the harvest from our motel window, so I stepped out to the edge of the field to capture a panorama of the adjacent fields. Early in my career, I studied the dynamics of a control mechanism for combine header height. The results were published in Transactions of the ASAE: "Dynamic analysis of automatic control of combine header height" (volume 13, issue, 2, pp. 225-231). See why I just had to take this picture?



ASABE Fellow John Schueller, P.E., *Professor of Mechanical and Aerospace Engineering, Affiliate Professor of Agricultural and Biological Engineering, and Director of the Center for Manufacturing Innovation, University of Florida, Gainesville, Florida, USA.*

ANCIENT TERRACES

Evidence of agricultural engineering from long ago in Peru.



ASABE member John Lumkes, P.E., Professor, Department of Agricultural and Biological Engineering, Purdue University, West Lafayette, Indiana, USA.

CELEBRATING TEAMWORK AND NEW FRIENDSHIPS

The team at the Tumaini Innovation Center celebrates after utility vehicles were successfully tested by pumping water, generating electricity, and transporting material (using the attachments shown on the vehicles). As fun as it was to build the vehicles together and learn technical skills from each other, it was just as rewarding to learn about each other's cultures, backgrounds, foods, and languages.

ASABE member Paul Funk,
Research Agricultural Engineer, USDA-ARS
Southwestern Cotton Ginning Research
Laboratory, Mesilla Park, New Mexico, USA.

MACHINE HARVESTING OF CHILI PEPPERS

Dr. Stephanie Walker, an agronomist at New Mexico State University, tests new cultivars of chili pepper to determine how compatible they are with mechanical harvesters. Over the past ten years, her selections have resulted in increased harvest efficiency and less fruit damage for fresh market green chili peppers, a regional specialty.





ASABE member Jason Schuster, Engineer,
John Deere Product Engineering Center, Waterloo, Iowa, USA

IOWA FARM

My parents' farm is in eastern Iowa. The barn was raised by my grandfather long ago. It's had some work done over the years, but it's still very much the original structure from all those decades past.



ASABE member Shane Williams,
Design Engineer, Kuhn North America, Inc., Brodhead, Wisconsin, USA.

RIISING TO THE OCCASION

Photographed during the 2018 ASABE Annual International Meeting in Detroit, this high-rise tower reaches dramatically into the night sky.

Editor's note: Every ASABE event offers photo opportunities. Take your camera to the 2019 AIM in Boston this summer, and capture a few images for our next *Visual Challenge*.





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The Fourth Industrial Revolution

Joel Cuello

Suddenly, in the latter half of the second decade of the 21st century, the world has awakened to a new industrial era. Charles Schwab, Founder and Executive Chairman of the World Economic Forum, has pointed to a Fourth Industrial Revolution as the world's next major industrial era.

The First Industrial Revolution harnessed water and steam power to mechanize production, the Second used electric power to create mass production, and the Third exploited electronics and IT to automate production. The Fourth Industrial Revolution combines advances in robotics, artificial intelligence, biotechnology, nanotechnology, quantum computing, the Industrial Internet of Things (IIoT), additive manufacturing/3D printing, and fully autonomous vehicles, among others, in the design of breakthrough engineered systems at the intersections of the physical, the digital, and the biological.

For agricultural and biological engineers—who have been innovating at these intersections for the last four decades—this new industrial era vindicates what we have been pursuing all along, and it shines a spotlight on our role in addressing one of humanity's grand challenges: designing resilient and sustainable food systems for the planet. Because ag and bio engineers have a head start on the Fourth Industrial Revolution, what types of engineers can we become in this new era? There are at least three: innovationeers, sustainavisioneers, and entrepreneurs.

Innovationeers

By proactively selecting technologies and tools from multiple disciplines, industry sectors, and professions, ag and bio engineers are adept at designing data-driven biophysical systems that offer effective, creative solutions. This is true in all areas of ag and bio engineering—from water and the natural environment to bioprocessing, machine design, electronics, biotechnology, and controlled environment agriculture. Vertical farming, a spinoff of NASA's Controlled Ecological Life Support System, is a notable example of the data-driven, biophysical systems that are emerging worldwide. Ag and bio engineers got there first, and we continue to make significant contributions.

Sustainavisioneers

Ag and bio engineers have also been pioneers in the design of regenerative or closed-loop systems in the service of a circular economy. In vertical farming, once again, we design innovative strategies to optimize the efficient use of essential inputs, such as water, energy, nutrients, space, and labor. Cuello's Law, a projected goal in the vertical farming industry, states that crop productivity with respect to resource use in a tech-dense indoor farm should double every four to

five years. This means that tech-dense vertical farms should achieve a doubling of crop productivity per liter of water, per kilogram of nutrients, per kilowatt of energy, per square meter of land area, etc., at least every half decade in the next two decades. Vertical farming enterprises appear to be making significant progress toward this goal. For instance, Plenty, an indoor farming company based near San Francisco, claims that it can produce as much as 350 times more food per acre of land, while using only one percent as much water, resulting in vastly more efficient food production and resource use compared to conventional agriculture.

Entrepreneurs

With 2018 posting another record year for investments in ag tech, with more than \$1.5 billion invested in over 160 deals, compared to less than \$200 million invested in 31 deals back in 2007, ag tech has clearly grown from a niche of the capital investment world to its own investment sector. Disruptions in the retail food chain, changes in agricultural land use, increased focus on sustainability, and changes in consumer preferences have all contributed to the increase in ag tech investment. This creates unprecedented opportunities for companies that apply the broad expertise of ag and bio engineers. For instance, in July 2017, Plenty secured an investment package totaling \$200 million. In July 2018, another U.S. vertical farming company, Crop One Holdings, announced a joint venture with Emirates Flight Catering to build a \$40 million, 130,000 square foot facility in Dubai that will provide fresh produce for the roughly 225,000 meals that the catering company supplies to Emirates airline. Meanwhile, Boston-based Indigo Ag has secured the largest investment in ag tech so far, in the amount of \$203 million. This maturation of the ag tech investment sector will help expand the entrepreneurial cohort of ag and bio engineers.

Agricultural and biological engineers certainly contributed significantly to transforming America and the world in the 20th century. In the 21st century, as the nascent Fourth Industrial Revolution locates the center of gravity of transformational and value-creating engineered systems at the interfaces of the physical, the digital, and the biological—agricultural and biological engineers have become even more well-positioned to contribute meaningfully in the collaborative co-creation of a more data-intelligent, resilient, and sustainable world.

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