

IOWA STATE UNIVERSITY  
OF SCIENCE AND TECHNOLOGY

FY18 Board of Regents, State of Iowa, Annual Economic  
Development and Technology Transfer Report

PRESENTED BY  
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ECONOMIC DEVELOPMENT AND BUSINESS  
ENGAGEMENT, OFFICE OF THE PRESIDENT

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Economic development is a top priority for Iowa State University. Indeed, it is a **prominent goal in the university's strategic plan**, and the university is very proud of the tremendous impact it has on the state economy. **In 2016 Iowa State received the prestigious designation as an *Innovation and Economic Prosperity University* by the Association of Public and Land Grant Universities (APLU)**, the first university in Iowa to receive this recognition. As the APLU states, "The designation acknowledges universities working with public and private sector partners in their states and regions to support economic development through a variety of activities, including innovation and entrepreneurship, technology transfer, talent and workforce development, and community development."

The Office of Economic Development and Industry Relations (EDIR), which moved into the new **Economic Development Core Facility** in the ISU Research Park in June 2016, consists of the following key university economic development units that provide integrated and comprehensive business, technical, entrepreneurial support, and educational services to Iowa State's clients and partners:

- The ***Center for Industrial Research and Service*** works with business and industry to enhance their performance through service offerings in five general areas: technology, growth, productivity, enterprise leadership, and workforce.
- The ***Small Business Development Center***, administered by Iowa State, consists of 15 regional centers serving all 99 counties in Iowa. SBDC assists individuals interested in starting new companies and provides business services and counsel to existing companies across Iowa to solve management problems, to improve operations, to seek financing, and to pursue new opportunities. Iowa State also operates two regional centers.
- ***Pappajohn Center for Entrepreneurship*** serves entrepreneurs, provides entrepreneurial opportunities for students including a student accelerator, hosts statewide and local business plan and pitch competitions, and participates in university-wide academic programs in entrepreneurship, including an interdisciplinary minor in entrepreneurial studies, graduate courses, a major in entrepreneurship for business students, and a PhD program in entrepreneurship.
- ***ISU Research Foundation*** and ***Office of Intellectual Property and Technology Transfer*** protects, manages, markets, and licenses the intellectual property of ISU researchers and implements agreements related to research collaborations with industry.
- ***ISU Research Park*** provides a resource-rich environment including close proximity and easy access to Iowa State University for its tenant companies, which include start-ups and established companies that range from growing entrepreneurial ventures to global corporations. The Research Park offers high quality labs and office space, as well as numerous services and amenities that support the efforts of science- and technology-based organizations.

EDIR also serves as the gateway or portal to the university's expertise, capabilities, resources, and facilities that support and enhance economic development throughout the state. Thus, EDIR works very closely with other university units that contribute to the university's economic development efforts and impact, including the Office of the Vice President for Extension and Outreach, the Office of the Vice President for Research, and the academic colleges.

Iowa State pioneered the first statewide Extension Service in 1906. The extension experiment – universities actively transferring their research and expertise to every corner of

every state – was immensely successful across America and remains so today. Each year more than a million Iowans directly benefit from ISU Extension and Outreach programs. ISU Extension and Outreach in collaboration with ISU colleges impacts economic development in the state through all of its programs – Community and Economic Development, as well as Agriculture and Natural Resources, Human Sciences, and 4-H Youth Development.

ISU promotes economic growth in Iowa in a number of ways. We provide business and technical assistance to existing companies, we support the creation of new companies, we help attract new companies and entrepreneurs to Iowa, we create intellectual property and help move research ideas to the market, and we contribute to workforce and entrepreneurial development.

### **Business and Technical Assistance**

During the most recent full year for the program, the **America's SBDC Iowa**, provided business assistance to individuals and companies **in all 99 counties totaling 4,044 clients** and 14,065 counseling hours. As a result of this counseling, **293 new businesses** were started and **1,845 jobs were created**. Additionally, SBDC assistance was credited by clients with increasing their capital infusion by more than \$108.6 million and increasing their sales by more than \$111.8 million. **This translates into 153 new jobs every month, 24 new business every month and sales increases of \$9,317,285 every month.**

The **ISU SBDC regional center and the Mid Iowa SBDC regional center**, in partnership with the ISU Pappajohn Center for Entrepreneurship, provided 2,193 hours of counseling assistance to startup and existing companies; **served 746 clients with one-on-one counseling; educated 184 attendees through workshops**; provided advice to several hundred clients via telephone and e-mail; and advised a number of technology companies in the areas of licensing, equity-based financing, market entry, and numerous operational areas. The centers **documented 53 new business starts with 262 new jobs created** that have generated **\$27,484,432 in capital infusion** and **\$8,980,707 in sales increases**.

**CIRAS** has been working with companies in communities across Iowa for more than 50 years and has a vision for Iowa of healthy communities through business prosperity. **Cumulatively, over the past five years, CIRAS and partners have reported impact from companies totaling more than \$2.5 billion dollars (\$2.2 billion in sales gained or retained, \$226 million in new investments, \$91 million in costs saved or avoided) with 28,043 jobs added or retained as a result of the assistance received.**

Last year, **1,705 businesses from 95 counties** in the state received assistance on projects or attended educational workshops from CIRAS staff or partners. Companies responding to surveys reported **\$621 million in total economic impact** — \$527 million in sales gained or retained, \$75 million of new investment, and \$19 million in costs saved or avoided. Company executives stated that **4,954 jobs were added or retained** as a result of the assistance they received from CIRAS and its partners. The following summarizes the results of the five primary CIRAS programs for this past year:

- The **CIRAS Procurement Technical Assistance Program (PTAP)** works with Iowa businesses, from one-person operations to some of the state's largest employers, to help them understand the government procurement process and to secure contracts. CIRAS is the only organization in the state of Iowa that provides contracting assistance at all three levels of the government market segmentation—

local, state, and federal. Last year, CIRAS staff **provided assistance to 863 companies**, resulting in an economic impact of **more than \$163 million**. The Defense Logistics Agency, which funds CIRAS to provide assistance to Iowa companies, indicated this impact **helped create or retain 3,262 jobs**.

- Last year, **603 small- to mid-sized manufacturers** received assistance under the **Manufacturing Extension Partnership (MEP)** program. Companies responding to third party surveys reported nearly **\$426 million in financial impact** from technical assistance and workshops on technology, growth, enterprise leadership, and productivity.
- CIRAS' Economic Development Administration University Center Program (EDAUCP) focuses on growing small businesses by coaching them on how to develop and commercialize innovative new products, processes, services or business models. Last year, 98 distinct clients received assistance under the program.
- The CIRAS Technology Assistance Program (TAP) has a mission to assist Iowa companies with technical problems and advance R&D activities. The program is comprised of two segments that support Iowa businesses in unique ways: the technology assistance group (includes materials, non-destructive evaluation, and engineering) provides shorter-term technical assistance, while the research cost-sharing program helps Iowa companies access ISU's faculty and facilities for research by providing a 1:1 cash match on research projects. Last year, CIRAS provided **technology assistance services to 379 distinct businesses**. Companies responding to surveys reported **\$164.1 million of total economic impact and 375 jobs created or retained** from the technology services they received.
- The CIRAS Community Assistance Program (CAP) provides community leaders and economic developers with the education and tools to develop and implement strategies to increase industry engagement, better attract and retain industry, and cooperate to solve critical workforce issues. Last year, CAP served 44 distinct clients through 9 events and 15 counseling sessions.

**Appendix 1** provides some illustrative examples of CIRAS, SBDC, ISURF and ISU Extension and Outreach projects with Iowa companies and entrepreneurs during the past year.

**During the five year time frame FY2012-2016 more than 13,700 different companies in Iowa representing all 99 counties benefitted from CIRAS and SBDC business and technical assistance and/or education/training services.**

This past year the **Community and Economic Development (CED) program within ISU Extension and Outreach** has multiple community development specialists in place with expertise and/or experience working with minority-owned businesses and community business leaders. During the past year, these specialists **helped 28 minority-owned business owners start or improve their own businesses, and assisted with the creation and the retention of 12 jobs for minority employees.**

### **The ISU Research Park**

The ISU Research Park (ISURP) has realized great success because companies find value in a close physical presence to the university as it facilitates working with faculty and graduate students on research, tapping into and recruiting the graduate and undergraduate

student talent pool, and accessing university facilities. ISURP tenants include companies of all sizes and industry focus, though engineering and technology, and bioscience comprise the largest proportion, reflecting Iowa State's strength in STEM. Tenants include companies incubated at ISURP as well as established global brands. **Four of the last five Iowa companies to go public started and reside in Ames, with three getting their start at ISURP Park and two still located there.**

Today, ISURP is a 400-acre development just south of campus with approximately 800,000 square feet of building space. **Twelve new companies and affiliates, and 31 pre-incubator companies joined ISURP in FY18, bringing the cumulative total to 364 companies and 6,006 employees for current and former tenants that are still in existence world-wide.** Currently, there are **87 companies and research centers and 11 affiliates located at ISURP, employing 2,155 and 135 people, respectively.** There are 18 pre-incubator companies that remain in ISU Startup Factory space.

In June 2016, ISURP launched the **ISU Startup Factory** to provide a stronger support system for students, faculty and staff wanting to create scalable businesses that address technical, societal or other challenges. Entrepreneurs in the Startup Factory receive formal training, resources, and access to a network of business mentors, advisors, counselors and investors in two 26-week blocks: the first a formal curriculum centered on business validation, and the second, customized to their individual business needs. To date, three cohorts have completed the program and two are currently in the program for a total of **53 new startup companies.** Graduated companies have **raised more than \$20 million** in private and public capital, including nine SBIR Phase I grants, three SBIR Phase II grants, eight Proof of Commercial Relevance awards, six Demonstration Fund awards, nine angel investment rounds and three institutional investment rounds. Additionally, these companies have created 66 jobs. The ISU Startup Factory partnered with four regional SBDCs and community colleges in northwest Iowa to launch the Startup Factory Network, a new initiative which brings the Startup Factory program to rural entrepreneurs developing scalable businesses through virtual weekly sessions.

### **Workforce Development**

A key component of the university's value proposition related to economic development, and its primary mission, is providing a world class education that provides students with the technical, analytical, problem-solving, communications, and social responsibility skills required in today's workplace. Iowa State is the largest university in Iowa with nearly **35,000 students**, and despite our Midwest location, our student body is quite diverse. Total U.S. multicultural and international enrollment at Iowa State is 25.2% of the student body (14.7% multicultural and 10.5% international). Our students represent every Iowa county, all 50 states and 126 countries. This diversity leads to a wide array of perspectives, capabilities, and ideas that enrich the learning environment. Not surprisingly, our graduates are in high demand and we have a **campus wide placement rate of almost 94%** (i.e., 94% of undergraduate students are employed in their field or are pursuing graduate education within six months of finishing their undergraduate studies).

**Iowa State is well known for providing students with professional development activities on campus that provide great opportunities for companies to utilize our students' talents.** We have excellent entrepreneurship programs in every college as well as "experiential learning" centers that provide opportunities for cross functional teams of students to work on business projects. **Each year more than 200 Iowa State students intern at ISU Research Park companies.** Additionally, engineering students complete a

senior capstone project, and several faculty across campus integrate company projects into their courses.

During the summer of 2018, the **Pappajohn Center for Entrepreneurship** sponsored the third cohort of CYstarters, a 10-week summer accelerator program for students. **Nineteen students on 15 business teams** who participated in the Center's various pitch and business plan competitions throughout the year **were selected to spend the summer in a hands-on mentoring environment at the ISU Research Park to launch and grow their companies.** Students participated in educational sessions, received mentoring, and essentially interned in their own companies instead of working elsewhere during the summer. All 15 businesses successfully launched. Twelve (12) of the twenty (20) total businesses from the previous two year's cohorts are still active and have gone on to be successful in state and national competitions. Also, 7 of the 12 have received state funding or private investment.

In 2017-18, the Pappajohn Center for Entrepreneurship launched a series of pitch and business competitions within each of Iowa State's colleges to help educate and identify student entrepreneurs across campus. Nearly 200 students competed, a number of whom received financial support for their fledgling concepts and went on to participate in national competitions and entrepreneurship accelerators.

The Iowa State Pappajohn Center works collaboratively with the other four JPEC programs to host a statewide student competition, a statewide Iowa entrepreneur competition, a weeklong entrepreneur summer boot camp in Okoboji at the Lakeside Lab, and a fellowship with Entrepreneurs Organization Iowa. Through these programs and support this year from IEDA, the JPECs awarded \$120,000 in incentives for entrepreneurial ventures.

Additionally, the Pappajohn Center for Entrepreneurship **placed 44 student interns in startup companies located at the ISU Research Park**, and reported **close to 3,000 students enrolled in entrepreneurship-themed coursework** across campus. **Over 7,500 individuals participated in programs and classes focused on entrepreneurship, startups and small business.**

The CyBIZ Lab interdisciplinary student consulting program offers business solutions to companies of all sizes as well as supports faculty commercialization efforts. The improved performance resulting from these interactions allow businesses to retain and often expand their workforce. **Seventy (70) CyBIZ Lab students working part-time completed 32 consulting projects** and additionally facilitated several live case classroom projects that gave students the opportunity to work with actual businesses to solve business problems.

CyBIZ Lab has established a number of partnerships across campus that have expanded the learning opportunities for students and significantly increased the impact students have had with real businesses. **CyBIZ Lab completed two (2) projects concurrently with mechanical engineering senior design cases**; paired up to performed **market validation research with twenty-four (24) technology transfer projects that had received RIF funding** through EDIR, with another six (6) tech transfer projects underway fall 2017; partnered with the Ivy Colleges of Business on internal curriculum and program research projects; and collaborated with ISU Extension and Story County Conservation Model Farm creative agency on a number of community projects. CyBIZ Lab students played a role in Iowa State's APLU Innovation & Economic Prosperity award, and its project with the Des Moines MPO helped the organization achieve the Technology Association of Iowa's "Best User of Technology" award.

As part of normal operations, CyBIZ Lab works with clients that include startups, non-profit organizations, government agencies, communities, college administrators, national professional organizations, small and medium sized businesses, and large global companies. CyBIZ Lab is unique in that teams are interdisciplinary and include both undergraduate and graduate students working together; projects also have a flexible timeline outside the classroom schedule, which allows teams to be highly responsive to company needs.

Senior capstone design projects are the culmination of engineering education for undergraduate students. Iowa companies, through a partnership between CIRAS and the College of Engineering, provide students with challenging opportunities to apply their engineering knowledge to real-world applications as a final step in preparation for joining the workforce. By working with the students, companies gain a new perspective on difficult engineering problems as well as the value engineers bring to an organization. As a result of the projects, many companies achieve innovative solutions that lower costs and enhance quality and productivity.

Last year, **engineering students worked on 158 projects, 131 of them with Iowa companies. This included 80 different Iowa companies across 34 Iowa counties.** Companies responding to surveys reported **impacts of more than \$63 million** for these projects.

ISU's College of Engineering Community Outreach offers high quality STEM programming to create and deliver experiences that engage, educate and inspire students of all backgrounds with a focus on creating an engineering pipeline to support workforce and economic development in Iowa and the nation. We help companies get the best ROI and develop strategy and planning to impact their communities and talent expansion through engagement with K-12 audiences including students, educators, and parents. We also work to increase the diversity of STEM students and increase exposure to career pathways through various programs to K-12 audiences including FIRST® LEGO® League (FLL) and FLL Jr., engineering kids camps, Iowa Manufacturing Day and more. **Youth participating in past summer camp offerings included 30 percent underrepresented minorities and nearly 50 percent female participants.** Increasing the gender equity in STEM is also evidenced by strong female participation of nearly 40 percent in FLL Jr. with the program exceeding growth metrics for the third year in a row. Events are held with partnering industry and civic organizations to increase reach to underserved communities. From its inception in 2002, the community outreach programs have grown to serve over 700 FLL and FLL Jr. teams participating in over 50 statewide events each year with more than 1000 annual volunteers from across the state collaborating with the college's STEM efforts to impact future workforce development.

In addition to professional development opportunities on campus, ISU's career services offices work closely with companies to assist them in establishing internships for our students. Internships provide students the opportunity to apply what they are learning on campus as well as the opportunity to experience firsthand the type of work environment they will be entering after completing their studies. Companies benefit from the interns' work output (many companies calculate a return on investment for their internship programs, and the returns are impressive), and they use the internship as a testing ground for prospective new employees. This past year our career services offices were able to document **nearly 2,400 ISU interns who were employed by more than 1,000 different Iowa employers located in 268 communities in 89 counties.** These numbers do not include students who

did not register their internship nor do they include students who had non-internship jobs related to their field of study.

**Iowa State also contributes to workforce development in the state by supporting students' learning and skill development even before they get to the university.** For example, Iowa State University's North Central STEM Hub, one of six regional hubs of the Iowa Governor's STEM Initiative, has been connecting education and business to increase student interest and ability in STEM. The North Central STEM Hub has hosted STEM festivals at the Iowa State Fair, Fort Dodge and with WiSE at Iowa State University, where families engaged in hands-on STEM activities hosted by formal and informal K-12 educators, community colleges, businesses, and economic development organizations. **The North Central STEM Hub supported more than 200 educators and more than 11,000 K-12 students** in the region with STEM Scale-Up programs in an effort to increase the students' interest and ability in STEM. ISU Extension and Outreach professionals play a significant role in each region through representation on each of the six Regional Advisory Boards.

**4-H Youth Development prepares Iowa's young people for future careers.** Youth develop communication, civic engagement, leadership, STEM, healthy living, and general learning skills by participating in 4-H educational experiences. Youth are challenged to actively pursue careers and/or education beyond high school and build skills that improve their communities and world. In fact, annually about 91 percent of 4-H seniors report they intend to pursue trades or post-secondary education within 12 months of graduation. 4-H programs reach more than 100,000 Iowa youth every year.

- Last year, there were 31,045 project enrollments in Leadership and Civic Engagement (formerly citizenship) curriculum, which not only aids youth in developing leadership skills, but encourages them and develops them as leaders in their home communities, today and in the future.
- There were 48,815 enrollments in the Healthy Living project areas, including food, nutrition, health, and fitness. As Iowa continues to struggle with the percentage of its citizens who are obese and who lack physical activity, this is critical education for the overall health of Iowa communities.
- More than 6,700 youth completed Food Safety and Quality Assurance training that is required to be certified to show livestock. Nearly 92 percent of the youth indicating their increase in both ag production knowledge and applying that knowledge to management and animal care changes in their own operations.
- STEM continues to be a very strong component of 4-H, with more than 127,500 project enrollments. However, there is more work to be done, as 40 percent of the youth reported improved STEM processing practices. Iowa 4-H has invested heavily in the last year on curriculum development and vetting. Strengthening 4-H STEM curriculum is a priority to improve this measure.

Finally, several ISU units provide training and related educational activities to a wide variety of individuals, occupations, and industries across the state. **Appendix 2** provides several such examples.



## **Technology Transfer**

In FY18 ISU researchers submitted **145 disclosures of intellectual property**, and our technology transfer office **filed 89 patent applications**. Forty-two patents issued in FY18, and in calendar year 2018, ISU was 86<sup>th</sup> on the list of the top 100 institutions with issued U.S. utility patents (32). Additionally, last year ISU technologies resulted in **51 license and option agreements worldwide with 21 in Iowa**. ISU currently has **185 license and option agreements yielding income. Iowa companies earned \$36.9 million revenue from ISU licensed technologies in calendar year 2016, and two startup companies based on ISU technologies were formed in Iowa**. Globally, total sales revenues from ISU licensed technologies were **\$121 million**, not including germplasm.

The **Regents Innovation Fund** program at Iowa State has a competitive research component that pairs ISU faculty members with Iowa industries (primarily new to young startups) to create economic benefit for the companies. Please see **Appendix 3** for a complete report on Regents Innovation Fund uses and results.

## **Research**

ISU promotes economic growth in Iowa through its research, conducting basic research which is at the foundation of many innovations in the marketplace, and collaborating with companies on their specific research and development initiatives to help them introduce new products and services and improved methods for creating and delivering these new offerings. We excel at developing collaborative relationships with companies so that our groundbreaking research can be put to practical use to not only improve business practices but also improve lives.

ISU had a record setting year in FY18 with **total sponsored funding of \$509.2 million, including \$245.8 million for research**. Businesses, corporations, and commodity organizations accounted for \$26.8 million of sponsored funding.

In FY18, ISU also made significant progress in supporting the State of Iowa's bioscience economic development platforms. In the first half of the FY, ISU completed its work in convening research groups, industry representatives and government stakeholders to share information on assets and growth areas with TEconomy, hired by the Iowa Economic Development Authority (IEDA) to identify and develop plans for Iowa bioscience platforms. With release of the TEconomy report at the end of 2017, Governor Reynolds announced Iowa's economic development roadmap for biosciences, which includes focused development of biobased chemicals, precision and digital agriculture, and vaccines and immunotherapeutics, and medical devices. These platforms were selected because of the alignment with Iowa's significant assets in these areas and the potential for significant market growth in each platform. Collectively, bioscience markets have grown by **57% since 2005**, and in Iowa, represent over **1,266 businesses** that provide a high concentration of employment compared to the national average and average salaries that are **61% higher** than overall private sector Iowa averages. The Governor's announcement kicked off a planning process at IEDA and on the ISU campus. As a member of the IEDA's Iowa Bioscience Development Center (IBDC) steering committee, ISU has worked closely with IEDA and our University of Iowa partner on this committee to establish the IBDC, which is expected to provide cross-cutting coordination for the platforms among industry and university partners, venture capital development, marketing and other functions for

economic development. In addition, ISU has begun developing plans for 3 of the 4 priority bioscience platforms, namely biobased chemicals, precision and digital agriculture, and vaccines and immunotherapeutics. ISU initiated this process with the biobased chemicals platform, and has been working with industry partners throughout the bioproducts value chain to sketch a system that would establish support for biobased products industries and accelerate transfer of ISU research discoveries to the market place. Using this initial planning process, early work is also being conducted to initiate a planning process for the other two platforms. These platforms all leverage significant strengths and assets at Iowa State and in the State of Iowa. These include the National Science Foundation's 10-year \$60M investment in the **Center for Biorenewable Chemicals**, which has led the development of approaches for creating value-added biobased chemicals from plants and has spun off **eight startup companies** in the past five years; as well as the **Bioeconomy Institute**, which focuses on biobased energy and value-added products through sustainable strategies. The precision and digital agriculture platform builds on ISU's **Plant Science Institute**'s strengths in integrating plant science, engineering, and predictive analytics to advance this technology sector with strong potential for innovation and growing startup activity in central Iowa; as well as research leadership in **Agricultural and Biosystems Engineering**, the top-ranked graduate program and number 2 ranked undergraduate program in the US. ISU's vaccines and immunotherapeutics platform builds from significant expertise with production animal disease prevention, diagnostics and management through the **College of Veterinary Medicine** (including the Veterinary Diagnostic Lab); the **Nanovaccine Institute**, which represents 70 researchers from 21 universities, research institutes, national laboratories, and companies, to revolutionize prevention and treatment of diseases with nanovaccines; and partnerships with USDA regulatory and animal health facilities in Ames. All of these platforms have significant industry presence in the ISU Research Park and throughout the State of Iowa. ISU continues to work collaboratively with the State and our partners at the University of Iowa to aggressively promote interactions among researchers and industry stakeholders, maximize the effectiveness of research developments, leverage state resources aimed at accelerating Iowa's economy, and translate research developments to significant economic development in Iowa.

### **Assistance to Communities**

Assistance to Iowa communities is the focus of many of the programs managed by ISU Extension and Outreach. Some examples of direct economic development assistance to Iowa communities are provided below.

**CED specialists provide skills training** each year for more than **50,000** community leaders, local government officials, business owners, entrepreneurs and volunteers.

**Community Development Specialist** On May 2, Kameron Middlebrooks joined Iowa State University Extension and Outreach's Community and Economic Development (CED) unit as a community development specialist focusing primarily on **African and African-American small businesses and nonprofits**, working to build strategic partnerships to help identify areas of collaboration that can help businesses and organizations thrive in Iowa's urban communities.

### ***Local Government Programming***

The CED unit, in collaboration with the Iowa League of Cities, will be taking on activities conducted by the Institute for Public Affairs, including strategic planning and goal setting for local and regional governments and training on a wide variety of legal, fiscal, and policy topics related to good government best practices.

### ***Student Involvement in Community Development***

In fall 2017, 18 upper-level Community and Regional Planning students prepared a comprehensive plan for the city of Mitchellville, with assistance from CED local government specialist Eric Christianson. The Office of State and Local Governments employed a student intern to assist in organizing and carrying out the 2017 Municipal Professionals Institute and Academy in July 2017. CED employs a graduate student intern to assist with a workforce study in Keokuk. In spring 2018, The Iowa's Living Roadways Community Visioning Program employed **11 student interns to assist in assessments and analysis in 10 communities.**

### ***Northeast Iowa Business Network (NEIBN) Workforce Attraction Study***

In FY18, CED received \$72,000 from the Upper Explorerland Regional Planning Commission to conduct a workforce attraction study in six northeast Iowa counties (Allamakee, Clayton, Delaware, Fayette, Howard, and Winneshiek. The objectives of this two-year study are:

- To analyze and synthesize previously drafted studies and plans for data, conclusions, and goals addressing the study area workforce and housing, and to determine gaps in the data requiring further collection efforts.
- To gather and analyze secondary data important to planning for workforce attraction and housing development that has not been captured in previous studies and plans.
- To gather primary data from workforce members in the six-county study region of their perceptions of the region's communities as places to live and work.
- Using the data synthesized and analyzed, to lead NEIBN members and other invited stakeholders in a facilitated planning session that will result in a written report and workforce attraction and housing action plan for NEIBN.

### ***Iowa's Living Roadways Community Visioning Program***

For the past 22 years, the Community Visioning Program has helped rural communities plan transportation enhancements using state funds from the Iowa DOT. To date, 238 Iowa towns have completed the process and collaborated with design teams to create conceptual transportation enhancement plans. The program continues to make a significant impact throughout the state.

### ***New Programming Initiatives***

In FY18, the CED unit began three new programming initiatives:

- **Leading Communities: A Place-Based Leadership Program** was developed by ISU Extension and Outreach CED and the University of Wisconsin-Extension. Based on cutting-edge community leadership research, it is designed to simultaneously provide participants with community-based skills while meeting the specific needs of the places where they live and work. In FY18, Leading Communities was taught in Buena Vista, Henry, Kossuth, and Lee Counties.
- The CED unit is now offering the **Marketing Hometown America** program that was successfully used by Cooperative Extension programs in Nebraska, South Dakota, North Dakota, and Minnesota to help communities home in on what people are looking for when they choose a place to live and do business. In FY 18,

communities in two counties participated in the program: Mapleton in Monona County, and Mondamin in Harrison County.

- The **Iowa Retail Initiative (IRI)** team, supported by the CED unit, has developed a three-part nested program to strengthen independent retail in Iowa's communities. The IRI Champions workshop provides training and resources for community decision makers and small business supporters. IRI Coaching works directly with retailers, preparing them for success with technical assistance and training. IRI Snapshots train local leaders to collect and analyze place-based information about their retail districts.

### ***Community Food Systems (CFS)***

The Community Food Systems Program is a multi-phased, multi-year program housed within ISU Extension and Outreach's Agriculture and Natural Resources program, Local Foods Team, and Community and Economic Development program. The program strategically partners with the ISU Community Design Lab for design assistance throughout the community process.

- In FY18, CFS worked in Pleasant Hill, nine counties in north Iowa, Dubuque County, Cass County, and Des Moines.
- The program received a \$270,000 AgMRC grant to develop Community Food Systems and Local Food Leader certifications.
- The program received a \$19,000 USDA grant to conduct a feasibility study for a food hub for Lutheran Services of Iowa.
- In FY18, the CFS program started a disaster recovery in farming assessment in St. Croix, which was hit by hurricane Maria in fall 2017.
- In January 2018, the program celebrated its fourth year of collaboration with communities across the state by hosting more than 130 partners: planners, farmers, local food coordinators, culinary professions, public health, and many more organizations across the state gathered to share success stories of community food systems development and implementation.
- In February 2018, the CFS program conducted a workshop to train approximately 40 people for Local Food Leader certification.

### **Major Economic Development Collaborations**

Iowa State University takes great pride and pleasure in its collaborations with both private and public sector partners. These collaborations are essential to achieving the university's and the state's economic development goals. The first four sections below identify new collaborations begun or formalized this past year. The remaining sections describe on-going significant state and regional collaborations.

#### **SBDC, Google, and Secretary of State Work together for small businesses**

America's SBDC Iowa is partnering with the Iowa Secretary of State and Google to ensure Iowa businesses have claimed their listing on Google and that the information is verified for accuracy. Through this joint venture, the SBDC has a presence in the Secretary of State's booth at the Iowa State Fair. The SBDC, Secretary of State, and Google are also presenting short workshops for businesses in an effort to help get Iowa businesses online and growing. SBDC staff working in the booth help small businesses find their Google listing and assist them to customize their listing. Businesses with complete listings on search engines are two times more likely to be considered reputable. Google is supporting the booth by providing giveaways for attendees and also provided training for SBDC personnel. This will also allow SBDC to provide additional services to small businesses in Iowa. The support from the Secretary of State's office is helping to expand the reach of SBDC services to businesses in Iowa.

***CIRAS Teams up with Iowa Economic Development Authority (IEDA) and Association of Business and Industry (ABI) to create “Year of Manufacturing”***

This partnership is developing and deploying a strategy to increase manufacturing output 10 percent by 2022. During the past year, CIRAS had significant engagement in increasing manufacturing networking, improving strategic planning, deploying new technologies and increasing productivity.

***CIRAS and Iowa Lean Consortium (ILC) Join Forces***

The ILC, a nonprofit founded eight years ago to promote business efficiency throughout the Iowa economy, announced a merger effective July 2, 2018. With over 130 member organizations from manufacturing, healthcare, finance, insurance and government, the ILC provides the philosophy, tools, and techniques to meet today's business challenges through members serving members. As part of CIRAS, the ILC will have the resources to expand their member-driven model and help more Iowa companies solve their workforce problem through developing their people and eliminating waste from processes.

***CIRAS Assisting Effort to Improve Iowa’s Targeted Small Business Program***

Iowa officials are working to streamline and improve Iowa’s Targeted Small Business (TSB) program, which provides purchasing preferences for designated Iowa companies that are owned and managed by members of certain disadvantaged groups. Over the past year, CIRAS has hosted a bi-monthly webinar for companies that have recently received their TSB certification. The webinar provides information on next steps and considerations to take advantage of the procurement opportunities for TSB's with the state of Iowa.

***CIRAS and University of Iowa technology collaborations***

CIRAS and UI’s MERGE prototyping hub called Protostudios has established a collaboration to support Iowa companies with advanced 3D printing technology. This new collaboration has already led to five projects with over \$2.5 million in impacts. The focus of the collaboration is to leverage unique technology located within ISU and Protostudios.

***Iowa State University Collaborates on Technology Transfer Services***

Iowa State University and the University of Northern Iowa (UNI) continue to partner in technology transfer. The partnership allows UNI to access Iowa State resources for technology transfer. UNI has the option to manage the protection and commercialization of their innovations, or they can opt to have the ISU Research Foundation provide these services. Iowa State is not charging a fee for this service, but sharing in income generated from the UNI innovations. In addition, Iowa State is engaged with Drake University to set up a similar collaboration to provide technology transfer services.

***ISU Partnership with Cultivation Corridor***

Iowa State University serves on the Board of Directors of the Cultivation Corridor, a regional economic development initiative to attract ag-bioscience firms to Iowa that was launched in April 2014. Other board members include Iowa Economic Development Authority, leading Iowa companies in the ag-bioscience industry, and Iowa commodity groups. ISU also serves on the Advisory Cabinet of the Executive Director of the Cultivation Corridor. ISU’s Office of Economic Development and Industry Relations works closely with the Cultivation Corridor, providing university expertise and services to support the Corridor’s efforts.

***Statewide Committees, Councils, and Task Forces***

Many representatives from ISU serve on committees that promote economic development programs. Those committees include the following: the Iowa Business Council’s Business-Education Alliance, the Iowa Innovation Corporation, the Biosciences Alliance of Iowa, Association of Business and Industry Advisory Council, the Iowa Lean Consortium,

Professional Developers of Iowa, the Iowa Business Council, Innovate Iowa, Technology Association of Iowa, the IEDA Advanced Manufacturing Working Group, Capital Crossroads, the Cultivation Corridor, and the Iowa Chamber of Commerce Executives.

### ***Midwest Grape and Wine Industry Institute***

The Midwest Grape and Wine Industry Institute, supported by ISU Extension and Outreach, was formed in 2006 by the Iowa Board of Regents as a result of the state's evolving grape and wine industry. The goals of the Institute are to:

- conduct research to evaluate cold-hardy grape varieties that can thrive in the Midwest;
- conduct enology research and develop vinification techniques;
- develop a wine quality award program that will provide wine buyers with a quality-assurance stamp of approval;
- establish an outreach program to the industry by offering training opportunities to cellar workers and winemakers;
- partner with community colleges to develop job training programs specific to growing grapes and making wine.

As of July 2018, Iowa had. Total wine production was 389,546 gallons in 2017, representing a 3.9 percent decrease in wine production since 2016. This followed a 20.2 percent increase from the 2015 to 2016 production years. Wine sales totaled 294,474 gallons. Wine sold at wineries represented 44.6 percent of sales, while the remaining 55.4 percent was sold at wholesale. The grape and wine industry in Iowa is maturing, but continues to grow. According to a 2012 study by Frank, Rimerman + CO. LLP, the economic impact of the Iowa wine and grape industry on the state's economy is \$420 million.

### **Future Plans**

Iowa State University greatly appreciates the resources and support that it receives from the Board of Regents and the legislature to carry out its economic development initiatives and activities. The primary purpose of this report is to show the huge economic and quality of life impacts we have been able to achieve for the state with the resources entrusted to us. The following sections identify how we plan to use additional resources to enhance the impact of university technology transfer and service on the creation of jobs and wealth in Iowa.

#### ***Small Business Development Centers.***

By helping its clients improve and grow their businesses the SBDC generates new tax dollars for the Iowa treasury in the form of sales tax revenue from increased client sales and income tax revenue from new jobs created by clients. In federal fiscal year 2017, SBDC clients generated an increase of \$111 million in sales, \$108 million in capital invested in Iowa businesses, and created 1,845 jobs. All information reported by the SBDC is verified and attributed to the assistance of the SBDC by the client through the client milestone collection process. SBDC is a good investment for the State of Iowa!

The SBDC also has a technology center designation allowing us to provide more in-depth counseling to entrepreneurs who have ideas or innovations that have potential for commercialization. Another advantage the SBDC provides for businesses is the cyber assessment for businesses. A business owner may visit [www.iowacyber.com](http://www.iowacyber.com) to learn about cybersecurity and their risk. Working together, we can create a stronger foundation of small businesses.

It should be noted that SBDC is working diligently to collaborate and partner with other organizations throughout the state, both public and private, to ensure that we are not duplicating efforts and to leverage each other's resources and efforts.

***ISU Pappajohn Center for Entrepreneurship***

The Center for Entrepreneurship is working diligently to expand opportunities for entrepreneurial learning and business support as part of President Wintersteen's campus-wide initiative in entrepreneurship as well as the Student Innovation Center scheduled to open in 2020. Collaborations with all of the colleges to increase programs, competitions, courses, workshops, and mentoring at Iowa State will result in more students, faculty and staff, and community members participating in entrepreneurial activities, thereby increasing economic development opportunities in Iowa and providing employment opportunities for entrepreneurial students upon graduation.

CyBIZ Lab's partnership with EDIR utilizing students to help validate business opportunities with faculty exploring technology commercialization based off university research will help with the goal of increasing the number of startups at the ISU Research Park, again providing potential employment opportunities in Iowa for students from across campus.

Support is needed to educate and provide engaging experiences for a growing number of students from all disciplines across campus who are drawn to entrepreneurship and innovation as well as provide support for fledgling entrepreneurs so that they can move past the idea stage and into business launch. Resources that seed new business concepts and help match expertise and skill sets for startups and growing businesses will continue to be a need at Iowa State.

***Iowa State University Research Park.***

ISURP is in the midst of a significant expansion, which has doubled the developable acreage and includes commercial amenities such as a restaurant, fitness center, child care facility, parks, walking and biking paths that are expected by young professionals today. This past year, McFarland Clinic and Lily Pad Learning Center opened their doors to the public, joining the already open Provisions Lot F (restaurant, coffee shop, bar, catering), Ames Fitness, NuCara Pharmacy, Lifestream Chiropractic and Studio7 Salon and Spa. Additional commercial projects are in the planning stages.

Also, this past year several more Iowa-based companies established operations in the Research Park to get better connected with the research expertise and infrastructure at the university as well as the workforce talent being developed on campus.

Any new funds to the ISU Research Park would be utilized to support costs associated with the expansion of ISURP as well as to increase efforts to attract and retain tenant companies.

***The Center for Industrial Research and Service.***

CIRAS has been supporting the growth of Iowa industry since 1963. Recently, staff assisted in the development of the Iowa Advanced Manufacturing Plan. See <https://www.iowamfg.com/reports>. The plan highlights a critical Iowa need, helping companies remain globally competitive by enhancing their digital readiness. Hundreds of Iowa companies need to substantially improve their operations or will be out of business within the decade. Specific needs include education and technical assistance in

cybersecurity, digital factory floor, design and engineering, supply chain data exchange, and enterprise support operations.

New funding of \$1 million per year for a digital readiness lab can be leveraged to bring in an additional \$1 million of federal grants and fees to provide digital readiness services to Iowa businesses. Historically, funding at this level has led to companies reporting \$100 million of new sales and investments and 1,000 jobs created or retained.

**ISU Research Foundation (ISURF)**

ISURF has been self-supportive since 1992 and over the past 10 years has returned more than \$18million to ISU and Ames Lab, in support of growing the research enterprise. New funds generated by ISURF will continue to be distributed according to the royalty sharing policy and funds in excess of what is needed to support the operation will be utilized to support the research enterprise, as recommended and approved by the ISURF Board.

**ISU Extension and Outreach.**

Extension and Outreach works across ISU colleges and with external partners to provide technical assistance, research-based education, and access to the resources of ISU to improve the quality of life in the state. Iowans want an economy that can form new businesses, grow existing industry, enhance communities, and recruit companies to the state. With Iowa STEM jobs expected to grow by 16 percent this decade, Iowans see the need to stop the “brain drain” and take steps to develop the state’s future workforce, connecting youth with opportunities here in Iowa.

With additional funding, ISU Extension and Outreach will expand economic development projects to broaden Iowans’ entrepreneurial aspirations with education and technical assistance. Extension and Outreach also will address the distinct needs of minority populations, as well as a burgeoning local foods industry and many struggling rural downtowns. These are only a few of the basic needs and urgent trends facing this state.

ISU Extension and Outreach expects to leverage every \$100,000 in new state funds with \$150,000 in new federal matching funds, grants, fees, and gifts to generate a projected \$2.5 million of impact and 25 new jobs throughout Iowa. For every \$100,000 of new funds, an estimated 2.5 additional staff will be hired to address growing demands and increase the depth and reach of work with families, businesses, and communities in all 99 counties across the state.

<b>Summary of ISU Economic Development and Innovation Data</b>	
a. Number of disclosures of intellectual property	145
b. Number of non-provisional patent applications filed	89
c. Number of patents awarded	42
d. Number of license and option agreements executed on institutional technologies:	51
in total	21
in Iowa	
e. Number of license and option agreements yielding income	185
f. Revenue to Iowa companies as a result of licensed technology (CY17)	\$36.9 million
g. Number of startup companies formed (through licensing activities) in total	2



in Iowa	2
h. Number of companies in research parks and incubators	
pre-incubator companies	31
private	70
university related	17
i. Number of new companies in research parks and incubators	
pre-incubator companies	28
private	12
university related	0
j. Number of employees in companies in research parks and incubators	2,155
Royalties and license fee income	\$4.3 million
k. Total sponsored funding received	\$509.2 million
How much of this is for research	\$245.8 million
l. Corporate sponsored funding received for research and economic development,	
in total	\$51.3 million
in Iowa	\$16.8 million
m. Iowa special appropriations for economic development, in total	\$2.525 million
SBDC	\$1.037M
CIRAS Technology Assistance Program	\$1.365M
ISU Research Park	\$0.122M
Regents Innovation Fund	\$1.050 million
n. Research expenditures (federal, state and local; business; nonprofit; institution funds; all other sources, FY17):	\$271.8 million
o. Licenses and options executed per \$10 million research expenditures (FY16 AUTM Survey))	3.8
p. Sales of licensed products by Iowa-based companies (CY17)	\$36.9 million
q. Number of employees for current Research Park tenants and incubators, as well as former tenants that are still in existence in basic form world-wide	5,029
Note: Unless noted, the data provided above are FY17 data.	

## **Appendix 1: CIRAS, SBDC, SIURF and ISU Extension and Outreach company and community projects**

The **Engineering Services and Products Company (ESAPCO)** has grown from a catalog business for farmers to a 390-employee firm with an industry-leading reputation for making greenhouses and tension-fabric buildings. ESAPCO has been deeply involved with CIRAS since 1990, when Iowa became its Midwest Distribution Center. In 2017, CIRAS and ESAPCO launched a nationwide strategic planning process that, among other things, aimed to make the company's Dyersville manufacturing plant more efficient. Benefits from the process are not yet known, but previous projects with ESAPCO over the past three years have had an economic impact of \$36 million. "We've used CIRAS frequently on projects, and found their professionalism and their experience to be second to none," said president of operations Dave Buchheit. "It's been a valuable relationship in the past, and we're looking forward to continuing to work with them."

**Kreg Tool Company**, Huxley-based manufacturers of the popular Kreg jigs, expects to save at least \$20,000 annually now that one of its most popular products is produced using a mold insert made via a project with CIRAS' metal additive manufacturing machine. The 3D-printed mold allows Kreg to take advantage of a process known as conformal cooling. Cooling channels built into the mold let the company keep better control of temperatures during the production process and eliminate several heat-related steps. Kreg therefore is able to make products more quickly and reallocate workers who once were required to handle its K5 jigs while they were cooling. "An injection molder is basically a money-printing machine," said Brian Hill, senior industrial engineer at Kreg. "The faster we can make the part fall out the more money we can make. Anything that can improve our productivity is something that can improve our cash flow."

**American Coating and Welding**, of Onawa, was founded in 2014 by a former Monona County sheriff's deputy who approached CIRAS with his dream for owning his own business. CIRAS government contracting specialist Andy Alexander spent more than two years mentoring owner Randy Lee. Alexander and CIRAS economic development program manager Mark Reinig guided Lee through everything from forming his company to finding the location for his business. Lee since has landed contracts working on Monona County and Iowa DOT vehicles, and CIRAS connections have helped him land work with three private companies. "There's a lot of paperwork, a lot of hoops to jump through just to understand what they're even talking about," Lee said. "I can easily say that we would not be where we are with the government contracting without your guys' program."

**Pengo Corporation**, based in Laurens, is one of the world's largest manufacturer of drilling attachments and related wear parts. In late 2016, they went to test an auger in front of a major client, and it failed. The company turned to CIRAS project managers Paul Berge and Adam Boesenberg, who quickly diagnosed the problem as improper heat treatment. The surface of the steel had been made to lose carbon, making it much weaker. Eric Matthias, director of business development/engineering for Pengo, later valued CIRAS' work on the project at \$450,000 – partly because the corrections helped Pengo land new business and avoid expensive third-party testing. "They've been huge for us," Matthias said of CIRAS. "I actually just sent two more of my engineers down there to work with them again."

**The Dimensional Group**, a Mason City custom packaging and commercial printing firm, was in difficulty by the time it discovered CIRAS. The company had stretched beyond its capabilities, and the shop floor was chaos, where work languished uncompleted and a backlog continued to grow. CIRAS helped the company reevaluate its growth plans, revamp the way it handled inventory, reorder the way business was done on the shop floor, and refocus the way management decisions were made. CIRAS also led a strategic planning effort that helped President Adam Gold pull back from day-to-day problem solving and lead the company. "It was

one of those things where I needed some new thinking to figure out how I needed to do it next,” Gold said. “That’s the great part about CIRAS. You have a group of professionals that are experts in what they do, and you have access to them. Whatever we want help with today, tomorrow, or the next day, it’s there.”

**Advanced Media Production Firm** is a creative and production strategy company that does business as Cocoa Creative. The Des Moines-based company worked with CIRAS to get registered as a HUBZone disadvantaged business. If federal authorities approve, the designation will give the company special preference in the awarding of certain federal contracts and open the door to potentially lucrative partnerships with other government contractors. “What we want to do is create jobs,” said company owner Terrence Thames. “We really want to create some economic impact and make a difference in that way.”

**VT Industries**, a Holstein-based door maker, first approached CIRAS in 2013 for help finding a replacement material for the fireproof core in its commercial doors. When CIRAS suggested several potential materials, what followed was roughly two years of research and testing, ultimately culminating in the 2015 construction of a \$10 million factory. VT since has hired 12 people to make fireproof doors using the new recipe. “Without CIRAS’ help, the process wouldn’t have been near as convenient or as quick,” said Ralph Scheidecker, plant manager at Creative Composites, a VT subsidiary that was involved with the project. “There are very few materials development projects that can go this fast to market.”

**WindSmart Systems** is a Des Moines-based manufacturer of commercial roof replacement systems. Their first conversations with CIRAS involved potential government contracting assistance. Then, the company requested help redesigning some airflow vents that it uses as part of its roofing system. Iowa State engineering students ultimately prepared a preliminary design that CIRAS’ Technology Assistance Program helped turn into a prototype part. “Without CIRAS, we would not have had this new innovative product,” said WindSmart marketing and brand manager Steve Pyle. “And it would not have been produced within our home state of Iowa.”

The **Iowa Lean Consortium (ILC)**, a statewide, member-led organization of 133 businesses, merged with CIRAS on July 2 after many months of discussions about ways the two could jointly help each other further their missions. CIRAS Director Ron Cox has announced plans to actively recruit new members into the consortium so that more Iowa companies can learn how to boost their productivity and operate more efficiently. ILC executive director Teresa Hay McMahon expects the merger to broaden the ILC’s reach and help the organization provide stronger support for its members. “Joining CIRAS will give us the resources to help our current and future members like never before,” she said.

**Gross-Wen Technologies**, an Ames-based startup company, reached a number of milestones in FY18. One of the key factors in their development was exclusively licensing an issued U.S. utility patent from the Iowa State University Research Foundation. ISURF is working with Gross-Wen to bolster its intellectual property portfolio, adding three additional patent filings on ISU-developed technologies. Gross-Wen followed these achievements with Iowa DNR approval for installation of their water treatment system and a two-million dollar targeted investment from an Iowa manufacturing company.

**Easy Energy Systems**, a Minnesota company with facilities in Iowa, continues to advance Iowa State University technology for second generation biofuel production towards commercialization. Having already licensed patents from ISURF, Easy Energy Systems turned to ISURF for assistance in licensing ISU-developed technology from a Fortune 100 company. ISURF renegotiated its agreement with the Fortune 100 company to allow Easy Energy

Systems access to this technology. Design and construction of a pilot production facility continues apace, with delivery of the first system expected in FY19.

**Jefferson-based American Athletic Inc.**, a leading manufacturer of sports equipment, turned to CIRAS for assistance with product and production development for a new product. The new training device for cheerleaders, called the Elite™ Cheer Stand, had a tight timeline to reach markets in time for Christmas. CIRAS staff utilized their plastics experience to support the product design along with their metal additive manufacturing system, commonly called a 3D printer, to create the required tooling in time. Senad Salkic, senior design engineer at American Athletic, praised CIRAS' help in designing the Elite™ Cheer Stand. "Additive manufacturing means CIRAS helped us keep our initial costs low, which results in a more affordable product for our customers."

**Preston-based Plastics Unlimited**, a 50-employee plastics thermoforming company is poised for significant growth after transforming the company (with CIRAS' assistance on both technical and business issues) from a contract manufacturer to an engineering-driven diversified company. "We're at the point where we could double in size in a month, or we could not grow at all," said sales manager Dakota Kieffer of the uncertainty associated with growth. Dakota and his brother Travis, recent graduates of ISU, have taken a leading role in diversifying the business from agriculture to include parts for rail cars, forklifts, and toothbrush makers.

**Rock Valley non-profit Double HH**, a subsidiary of Hope Haven Inc., is a vocational rehabilitation firm that uses physically or intellectually disabled workers to manufacture products for a range of industries. "We've worked with CIRAS a number of times over my 30+ years here, and it's been quite successful," said Loy Van't Hul, director of manufacturing operations. "CIRAS has always been good about approaching it the right way—just treating it like a business and adapting things slightly." Over the past five years, CIRAS has provided services in process improvement, worker training, and testing. It's produced an economic impact of more than \$1.2 million.

**Calhoun Communications in Sioux City** increased sales by more than \$400,000 through assistance from CIRAS in improving the company's ability to reach the federal government market. "[CIRAS] demystified the whole process," said Lance Martin, operations director. "We, for quite some time, had wanted to break into the federal market. This has opened the door to a much broader reach for us." He praised a CIRAS workshop on capability statements as especially useful in helping Calhoun approach new customers. "It's been amazing how powerful the capability statement has been for marketing our business," he said.

**Elgin-based Donlon Brothers** turned to CIRAS for help in transitioning from commercial excavation projects to city, county, and state projects. After attending a CIRAS networking event and receiving counseling in the Iowa Department of Transportation contracting process, the company successfully secured more than \$100,000 in bridge project subcontracts.

**Puck Custom Enterprises in Manning** has manufactured manure application equipment since 2005. Between 2011 and 2016, the company doubled its export sales. Company leadership reached out to CIRAS in 2014 to ensure that their approach to exporting was appropriate. Puck participated in ExporTech, a three-part educational program developed by the U.S. Department of Commerce. It's deployed locally by CIRAS, Iowa's U.S. Commercial Services office, the Iowa Economic Development Authority, and other CIRAS partners. Jeremy Puck said the ExporTech sessions essentially reassured his firm that Puck employees were going in the correct direction. Periodic difficulty with foreign paperwork and having products get trapped in overseas ports were common headaches, Puck employees learned, but they also made connections to solve

these problems as they occur. The 12 companies that have attended ExporTech in Iowa have reported more than \$35 million in new or retained sales and 99 new or retained jobs as a result of participating.

**Des Moines manufacturer Seneca Tank** brought a team of engineering students in to assist them in simplifying production tooling approaches. Rather than stationary tool boxes with more than 100 tools, students and company employees collaborated on a mobile cart that housed 20-30 of the most-used tools. S.J. Risewick, director of unit sales and production, said the college students were “much more approachable than a consultant. Our employees were much more engaged in educating them on our products and processes.” Risewick said the final design has made employees’ workdays much easier. “It’s reduced the walking time tremendously.”

**Donatech Corporation’s** decade-long relationship with CIRAS has helped the company’s Cedar Rapids arm broaden its reach into the world of government contracting. Donatech has attended a wide variety of CIRAS-provided training over the past five years and used a bid-match program provided by CIRAS that allows a businesses to view local, state, and federal opportunities specific to their industries. “The results have been really good in making a lot of favorable introductions to local companies that we might be able to partner with from a business standpoint,” said Pat Adam, vice president of strategic accounts. Additionally, Adam said the company received solid guidance from CIRAS about working with prime government contractors.

**Spencer Economic Developers** are partnering with CIRAS and the Iowa Area Development Group (IADG) to pilot a new approach to attracting manufacturers to rural communities. Over the past 30 years, IADG has partnered with rural communities to build 75 speculative industrial structures – most of which are filled. Now, CIRAS will engage with prospective companies to help identify and break down barriers to selecting these rural sites. “Historically, we’ve referred business to CIRAS many times over the years, but always they were existing employers in the region,” said Kiley Miller, president and CEO of the Iowa Lakes Corridor Development Corporation. “This is a new opportunity for us to use CIRAS as a business-attraction partner.”

Over the past several years, CIRAS has published four reports as part of the EDA program to develop and implement the Iowa Advanced Manufacturing Network (AMIN) program in the state. Studies and reports published to date include the following subsectors: Plastics and Rubber Manufacturing, Machinery Manufacturing, Metals Fabrication Industry, and Food & Beverage, Feed & Graining Manufacturing.

**Doreen Roy won the Deb Dalziel Woman Entrepreneurial Award in 2018.** Doreen’s entrepreneurial spirit started with her home-based business making skin care products in 1999. Today she owns and operates three businesses in Burlington, The Wholesome Basket, Gypsi, and Red Screen Door. Doreen is known for being passionate about giving back to the community and bettering downtown Burlington for fellow business owners and community members. She is very involved in Burlington’s Main Street Program, leading the marketing committee, and attending statewide meetings. Doreen is also passionate about helping other business owners and she serves as mentor to new business owners. She has worked closely with the Southeastern SBDC in Burlington and Regional Director Janine Clover.

**The 2018 Neal Smith Entrepreneurs of the Year were Brad and Angie Barber of Cabin Coffee.** Brad and Angie Barber noticed something missing from the small town of Clear Lake. The bustling tourist destination seemed to have everything except a cozy gathering place on Main Street. The Barbers founded Cabin Coffee in 2002 to fill this need. Once the idea was formed, the Barbers sought help from the North Iowa Area SBDC and Pappajohn Center to help with franchising and growing their business model. Cabin Coffee has continued to steadily grow over

the last 16 years and now has 15 locations with 13 of those being franchises across Iowa, Minnesota, Illinois, Wisconsin, Indiana, Colorado, and Georgia. Brad and Angie launched Cabin Coffee with the intention of rooting their family in the North Iowa region and are passionate about staying true to their origins and growing their business in North Iowa. With a deep commitment to the community, Cabin Coffee makes a point to work with other local Iowa businesses.

ISU Extension and Outreach's Community and Economic Development program (CED), Iowa Department of Public Health, and University of Iowa College of Public Health continue their collaboration on the **Shop Healthy Iowa** program. Store owners receive technical training in produce handling, assistance in redesigning store space to promote healthy eating choices to customers, and promotional materials. Sales of fresh produce have high gross profit margins for stores, magnified when the volume of sales increases. However, the risk in offering more fresh produce for sale lies in the greater energy and time investments required to realize those profits and the potential for increased inventory to perish before sales increase. Participation in the Shop Healthy Iowa program is designed to provide store owners with the needed assistance to increase sales of fresh produce. In FY18, the program was conducted in Sioux City (two stores), Davenport (one store), Storm Lake (two stores), Denison (one stores), and Des Moines (one store).

Through **ISU's Road Scholar Program**, local business owners received training on how to capitalize on tourism in Iowa. In 2017–18, 112 citizens, 56 community leaders, and 268 business leaders/entrepreneurs received assistance through these programs. As a result, 90 businesses were expanded or improved. The estimated dollar value of the jobs that were created or retained was \$87,000.

## Appendix 2: Training and Related Educational Activities

### Center for Industrial Research and Service (CIRAS)

CIRAS held its fourth annual **Iowa Vendor Conference** in Des Moines with a goal of helping Iowa business leaders gain a better understanding of how to do business in the government sector. More than 60 companies were able to expand their government contracting potential by attending diverse workshops, experiencing national-level keynote speakers, and networking with a variety of resource partners and buyers, such as the Des Moines Area Regional Transit Authority, Iowa National Guard, Iowa Air National Guard, and the Department of Transportation.

CIRAS hosted and participated in a total of 26 networking and matchmaking events across the state focused on government contracting. The events provided targeted one-on-one interactions focused on creating business relationships, networking to help companies learn best practices and develop relationships, and regional activities to expand networks and build relationships. Over the last year, nearly 400 attendees have participated in these events.

CIRAS continued its **Future of Manufacturing Series** to build Iowa's awareness and ability to deal with the next manufacturing revolution. Events covered included agile strategy, digital manufacturing, automation, leadership, cybersecurity, and artificial intelligence. More than 480 attendees have participated in the 18 months since launching the series.

The Iowa Economic Development Authority, CIRAS, the Iowa Farm Bureau and the U.S. Commercial Service continued to partner to deliver **export training** to Iowa companies. 200 attendees participated in a variety of in-person and web-based training sessions on critical topics including international banking, compliance, and NAFTA.

CIRAS expanded its successful ISU Lab Tour Program to include taking the event off campus. This recent effort to take ISU Lab Technology "on the road" is targeted at companies in the four corners of the state unable to attend the existing campus tours. Similar to campus tours, companies gain first-hand knowledge of technology that can support industry's innovation and quality objectives. The first two events reached 43 attendees. Plans for two additional events in the remaining two areas of the state are scheduled for this year.

CIRAS partnered with the Center for Crops Utilization and Research, the department of Food Science and Human Nutrition, and Meat Science Extension to expand **training tailored to food manufacturers**. Trainings included Preventative Controls Qualified Individuals (PCQI) Training, production and maintenance training, and advanced technology. Through these partnerships, we offered 38 trainings totaling over 1,100 attendees.

CIRAS hosted an **Innovation Summit** in December with 56 attendees from 23 companies focused on industrial automation. Several technologies were discussed or showcased at the summit including: cobot robotics, smart automation, automation integration, and custom automation systems. Attendees learned the barriers to successful automation and how to address them through several case studies. The summit has already generated impacts in excess of \$1 million.

Thousands of Iowans celebrated national **Manufacturing Day** throughout the month of October 2017. CIRAS led a team with the Association of Business and Industry (ABI), Elevate Iowa, community colleges, ISU Extension and Outreach, the Iowa Area Development Group and others to expose Iowans to the great careers available in modern

manufacturing. A total of 169 events were held across the state, ranking Iowa 5<sup>th</sup> nationally in number of events despite our relatively small size.

**Community and Economic Development (CED) in ISU Extension and Outreach** empowers communities to shape their own futures through research, education, community engagement, economic development, and community planning and design. CED has multiple community development specialists in place with expertise and/or experience working with minority-owned businesses and community business leaders. CED serves as an essential conduit between Iowa's communities and the resources of Iowa State University, creating partnerships with private and public sectors for the betterment of Iowans.

The **Data Indicators Portal**, a Vice President for Extension and Outreach initiative, provides web-based information products such as local retail trade analysis and demographic and economic indicators. Professor and extension landscape architect Christopher Seeger and GIS support specialist Bailey Hanson continue to update the Data for Decision Makers downloadable report. Users are able to access 2017 population estimates by county and city, as well as data on the median age by sex, the ratio of males for every 100 females, and total population by sex. County Health and 4-H Data for Decision Makers Reports are also available. CED staff conducted workshops throughout the state on using the website. In FY2018, the Indicators Portal had 13,367 page-views and 4,380 sessions by 2,532 users.

As part of the **Iowa Government Finance Initiative (IGFI)**, CED released city level annual fiscal conditions reports for all 945 cities in Iowa. In addition to including the up-to-date fiscal data for all the cities in Iowa for the year 2017, the reports also include the recently released U.S. Census data on select socioeconomic characteristics at the city level. The reports are the only source in the state of Iowa for cities wishing to access the most updated socioeconomic and fiscal information in a format customized with a narrative for every city in the state. In FY 2018, 412 county IGFI reports and 1,092 city IGFI reports were downloaded. In addition to the annual reports, IGFI provided local governments an alternate perspective about their financial health and performance and provided training targeted at elected officials and public employees. Using local government finance data, IGFI analyzes trends and financial performance of selected indicators. CED specialist Cindy Kendall trained local government leaders on the initiative.

The **Geospatial Technology Training Program** conducted three **ArcGIS** two-day short courses for a total of 32 planners and local officials from throughout the state. Six CED specialists participated in a Train the Trainer (T3) retreat to learn **Navigating Difference@ cultural competency training**. In FY2018, these specialists delivered the training to the United of Central Iowa, the City of West Des Moines, the United Way of Story County, and the West Des Moines School District.

**Agriculture and Natural Resources Extension and Outreach (ANR)** provides research-based information and resources to educate Iowa's farmers, producers, and agribusinesses. Much of Iowa's economy thrives on the state's rich agricultural heritage. ANR programs impact all Iowans, whether they live in rural or urban areas, and have been developed to improve quality of life. ANR specialists are engaged with farmers, researchers, organizations, agencies, agribusiness, and communities at state, regional, and national levels.

**Commercial horticulture programs increase fruit and vegetable production in Iowa.** According to the 2012 National Agricultural Statistics Service, total horticulture sales in Iowa equal \$123 million. ISU Extension and Outreach horticulture specialists work with fruit, nut, vegetable, nursery, sod, and greenhouse growers to enhance yield, quality, efficiency and safety, while food scientists and program leaders focus on providing safe and secure food supplies. For example:



- Extension programs reach segments of agricultural communities that are underserved or underrepresented and operate small farms, usually with limited resources. The vegetable production team has developed meaningful relationships with the Amish and Mennonite communities in Kalona, Iowa, and Elma, Iowa, and consistently helped to address their crop production, nutrient management, and pest management challenges. Working with their community leaders, several field days and workshops have been organized. Over the years these activities have increased production efficiency and productivity of several crops: broccoli, cucumber, onions, pepper, squash, tomato, and watermelon, in Kalona, Iowa.
- Programming is focused on the hops industry and supporting producers in Iowa. Since 2014, there has been a 900 percent increase in hop production (5 acres to 50 acres). With the Iowa craft beer industry bringing in over \$100.2 million in sales in 2014 the potential for these brewers to purchase locally grown hops is huge. As the craft beverage industry continues to flourish, the need for Iowa hops will continue to increase.
- “Growing Together” promotes healthy food access for families with low income through a partnership of ISU’s SNAP-Ed, Master Gardener volunteers, ISU Research and Demonstration Farms, and Iowa food pantries. In 2017, Master Gardener volunteers worked to provide fresh produce to food pantries throughout the growing season. Nearly 75,000 pounds of produce, which equates to nearly 225,000 servings of produce for food pantries, was grown and donated by the Master Gardeners. The average Master Gardener averaged nearly 60 hours of work during 2017, significantly more than the 20 volunteer hours each Master Gardener is required to provide. Those volunteer hours are valued at \$2.7 million spent improving Iowa.
- The **On-Farm Food Safety Team** (from College of Agriculture and Life Sciences, Human Science Extension and Outreach, and the Department of Food Science and Human Nutrition) have been leading two, million-dollar Food and Drug Administration grants focused on food safety for fruit and vegetable growers in Iowa and the North Central Region. Partnerships with 12 land-grant institutions in Illinois, Indiana, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, South Dakota, Ohio, and Wisconsin have been formed. Food safety educational information has been delivered to more than 2,000 growers in this region. Food safety needs assessments have captured the concerns of 1,200 growers. Four Produce Safety Alliance training sessions to educate leaders in food safety were held, and 39 Produce Safety Alliance grower trainings, reaching 800 growers, were also conducted. Through these efforts, 164 regional extension and grower educators can provide food safety training and technical assistance to fruit and vegetable growers. To further educate, two websites have been launched along with online tools that provide on-demand education to fruit and vegetable growers on food safety.
- More than 300 food hubs are operating in the United States, with at least 16 local food aggregators or distributors in Iowa alone. ISU Extension and Outreach Local Foods Program facilitates a statewide food hub managers working group and has developed a series of publications for that audience that address food safety, production planning, cash flow management and more. In 2014, a project to explore food hub activity and make recommendations that would support development of food hubs in Iowa was launched. The study found substantial interest in furthering food hub development in Iowa, and the first statewide study of food hubs was conducted. The study found that in 2013, **thirteen food hubs in Iowa purchased \$4.5 million in food from 459 Iowa farmers.** Overall, Iowa farmers sold more than \$13 million in local food to wholesale and intermediate markets in 2013. Food hubs also reported employing 58 people, though most were part-time. The study suggests

that even though food hubs are still an emerging sector, they are already having a substantial economic impact.

**Ag Decision Maker website.** Farmers, financial lenders, farm managers, and agriculture educators need current, unbiased agricultural economics and business information to make sound farm management decisions. The **Ag Decision Maker website**, [www.extension.iastate.edu/agdm](http://www.extension.iastate.edu/agdm), offers access to up-to-date information, including new and emerging issues critical to their success. This web-based resource supports many ISU Extension and Outreach farm management programs. From July 1, 2017, to June 30, 2018, the website averaged 7,451 visitors per day. Overall, downloads of information sheets and decision tools reached 1.26 million for the 2018 fiscal year while more than 240 information files, decision tools, voiced media, and teaching activity files were added or updated on the site. More than 15,000 users receive monthly updates highlighting the materials on the Ag Decision Maker site. The AgDM Twitter feed promotes materials and events throughout the month to 1,618 followers (an increase of 287 in the past year) and had 68,480 impressions during the past 12-month period.

**Iowa Pork Industry Center.** With specialists in the field and on campus, the **Iowa Pork Industry Center** works to promote efficient pork production technologies in Iowa, maintain Iowa's pork industry leadership, and strengthen rural development efforts. For example:

- Iowa producers had concerns about complying with the requirements of the antibiotic regulations as established in the FDA Guidance 209 and 213 policies. So six ISU Extension and Outreach swine specialists and the Iowa State Swine Extension Veterinarian collaborated with Iowa Farm Bureau, Iowa Pork Producers Association (IPPA) and the Iowa Beef Center (IBC) to develop and deliver workshops. The objective of the workshops was to help producers understand and prepare for the new requirement for treating animals with antibiotics and to help producers implement management strategies that reduce the need for antibiotics. Twenty-nine workshops and talks were presented to a variety of producers, agriculture professionals, and veterinarians, reaching 1,452 participants. As Iowa produces about one-third of the pork in the nation, health and safety is important to this industry. Over the past several years, our swine extension specialists have trained **more than 5,000 producers on how to implement bio-security protocols**. While the exact savings of the bio-security training is not known, even a small adoption of implemented changes in biosecurity result in a potentially large payback.
- Ongoing educational efforts have continued to **help swine producers improve judicious use of antibiotics**. Certification programs teach biosecurity, herd health, proper delivery techniques, following the label and methods and technology to minimize antibiotic usage. The IPIC team has certified 1,635 PQA plus and 812 TQA certifications with 300 PQA Advisor certifications via workshops and online over the past few years. Regional swine meetings focused on judicious use of antibiotics through three workshops for 114 participants. Additionally, specialized workshops have been developed and piloted for increasing herd health, thus reducing the amount of antibiotics used. Four specialized antibiotic reduction strategy workshops have been held to date for over 50 producers. A sample of 120 producers were surveyed (~6 month post workshops) to assess the impact of judicious use educational programming; 12 answered the survey. From the sample surveys, 20% indicated a change in antibiotic management, and another 80% changed management practices, such as hygiene and floor space to improve health, resulting in reduced need for medication. One operation out of 12 reporting changed weaning age to reduce antibiotic usage. Also 42% reported antibiotic usage reduction

because of management decisions regarding medication timing. Another 33% shifted from mass treatment to more individual treatment, thus reducing antibiotic use. About half the respondents reported less antibiotic usage through improved herd health practices learned at the workshops. Average dollar value reported per participant was \$1,875.

- A day-long conference was held in June 2017 for the Iowa swine industry. This **Sixth Annual Iowa Swine Day** had approximately 500 attendees. A total of 16 speakers with national and international reputations provided seminars that addressed topics such as misconceptions about the use of science in agriculture and issues associated with agricultural markets and consumer trends. Additional topics included updates on swine disease, new technology implementation, progress in the implementation of using veterinary feed directives, facility management, and updates from current swine related research from Iowa State University. Participants also reported using the information learned, leading to change of practice in their operations. Thirty-three percent used information regarding industry structure and managing heat stress, 41 percent used information to improve consumer relations and a quarter of participants applied gut health insights to their operations. Seventeen percent applied knowledge learned to engage the public and increase bio-security. The average estimated value reported per participant completing the survey was \$2,733.

**Iowa Beef Center.** Iowa ranks fourth nationally in number of cattle on feed and produces over 2,000,000 head of feedlot cattle on 6,000 individual operations annually. Resources provided by the **Iowa Beef Center** give producers the information necessary to increase their herds and update their operations.

- From 2012 to 2017, the Iowa Beef Center hosted more than 100 grazing programs attended by nearly 1,200 producers. Programs included pasture walks, statewide conferences, and multi-session series on grazing management. More than 50 pasture walks were held on farms featuring unique aspects of pasture management. Grazing series included: 5-session, beginner-level greenhorn grazing program held at 11 locations; 3-session, intermediate-level grassroots grazing program, co-sponsored with NRCS, offered at 10 locations; and 4-session advanced-level certified grazers program held at 9 locations. Participants in all forage programs were surveyed in the fall of 2017 to determine practices they have adopted or plan to adopt as a result of their participation. When surveyed, 960 of 1,200 respondents indicated that pasture productivity was increased by improvements made based on objectives learned at an extension forage program. Of the responses, 504 increased pasture productivity 10-20% and 396 said productivity increased more than 30%. In addition, more than 600 noted economic return of at least \$500 because of their participation. Not only were almost 1,200 producers impacted by an extension pasture or grazing program, but at least one component of the program was shared by attendees to an additional 1,300 people. Of those who responded to the post-event survey, 396 improved their ability to identify and manage tall fescue, 372 modified weed control and 372 developed watering systems. In addition, 288 implemented a grazing plan or re-established or renovated existing pasture, with more than 240 planning to do so in the future. Survey responses also indicated that 384 have incorporated cover crops into their grazing plan and 408 implemented pasture condition scoring.

- Now, perhaps more than ever, longevity is the key to profitability in Iowa's beef cow herds when it comes to replacements that entered the herd over the past two years. In 2016, the Iowa Beef Center conducted the third part of a heifer development series focused on selection and management practices that enhance longevity of the beef female in the herd. This program was built on two previous heifer development programs, which also have been distributed on YouTube for on-demand use. As a result of this program, more than 90 percent of the 235 meeting participants increased their knowledge of heifer retention economics and new selection indexes. More than 37 percent of participants plan to implement udder scoring and foot scoring, and 30 percent plan to calculate the net present value of their own females. Since this program, the Net Present Value of Replacement Females decision tool has been downloaded more than 1,700 times, the Buy or Raise Replacement Heifer decision tool has been downloaded more than 5,400 times, and the heifer development videos have been viewed more than 13,500 times. Change in producer knowledge as a result of this program will lead to an increase beef cow retention and increased profitability for cow calf producers, resulting in a strengthened Iowa agriculture and enhanced local economy.
- In response to growing concern about antibiotic resistance in human medicine, the Food and Drug Administration (FDA) developed rule changes to force more veterinary oversight and more judicious use of antibiotics in animal agriculture. The Veterinary Feed Directive (VFD) changes the way medically important antibiotics are purchased and used. More than 1,100 livestock producers, veterinarians and feed distributors in Iowa participated in workshops, webinars or podcasts to increase their knowledge of the new animal antibiotic use regulations, improve their management related to judicious use of antibiotics in animal production, and improve record keeping related to medication use. More than 80 percent of participants plan to change how they use antibiotics in animal production or improve their record keeping. They manage or impact more than four million animals.

**Transition Cow Health Programs.** ISU Extension and Outreach conducted **transition cow health programs** to increase awareness and operation profitability. While transition cow management encompasses only 20-30 percent of the herd at a time, it can ultimately influence the milk production and health of all cows in the herd. To assist Iowa's dairy producers in implementing better transition cow practices, an extensive 18-month program focused on transition cow practices and principles was delivered across the state: seven on-farm transition cow hands-on workshops were conducted; nine dairy day events were held; and three video modules were developed. In addition, 60 individual herd visits were conducted with 48 individual producers now working with transition cow projects. Survey results, which represent 20 percent of Iowa's dairy cows, indicated that more than half of the producers had made changes to their transition cow programs; producers gained increased production and lower veterinarian costs; and have benefitted from healthier calves and a decreased calf mortality rate. Overall, the program has resulted in \$400 more income per cow, or the potential of \$16 million gain for Iowa's dairy farmers.

#### **Manure Management.**

- ISU Extension and Outreach annually trains representatives from about 600 businesses and 2,400 employees who come from more than 90 counties in Iowa and the four surrounding states in the **commercial manure applicator program**. These businesses annually handle and apply about 1.5 million tons of solid manure and 3 billion gallons of liquid/slurry manure that has a fertilizer value of about \$250 million, while doing about \$70 million of business. The curriculum has focused on equipment

maintenance and selection to improve manure application uniformity. More than 70 percent of commercial applicators reported this information was useful to their business, with 30 percent reporting they would improve hose and distributor layout on their equipment and 8 percent reporting this would prompt them to select new equipment. These changes are estimated to increase corn yield by approximately 3 bushels per acre, or increase manure value by approximately \$2 million in the state of Iowa.

- In northeast Iowa during 2017, 28 **manure management** meetings were held to instruct farmers on how to maximize returns to crop fertilizer expenses. Over 260 clients attended the meetings. Post event surveys showed that on average, meeting attendees were able to make changes that reduced input costs by \$17 per acre. The results also showed that farmers are prioritizing fertilizer applications on fields that are most in need and reducing applications on fields with adequate fertility levels. Ninety percent of livestock operators now sample manure on an annual basis, and 61 percent reduced commercial fertilizer purchases by an average of \$24 per acre.

**Land Rental.** Roughly 13 million acres of Iowa's land is cash rented each year for crop production, pasture, and other purposes. ISU Extension and Outreach offers a variety of **tools to assist landlords and tenants in determining fair land rental rates.** In 2017, ISU Extension and Outreach farm management specialists conducted 89 leasing meetings across the state, with more than 1,600 landowners, operators, and ag business professionals attending. A post-meeting survey found that 18 percent of respondents indicated that they would decrease land rental rates for the following year based on the information provided at the leasing meetings. Twenty percent indicated they would improve communications with their renter. Iowa State's annual cash rent survey for 2018 found that typical cash rental rates increased by \$3 per acre. The **ISU Extension and Outreach Cash Rent Survey** was downloaded 207,289 times in 2016. Sample cash lease forms were downloaded 199,536 times. Videos on topics related to leasing were available after the 2016 meeting series, and were viewed 3,176 in the first four months they were available.

**The Pesticide Safety Education Program (PSEP)** provides information through a variety of venues on the safe and effective use of pesticides. Emphasis is placed on protecting human health and the environment while also including information on successful and responsible pest management. The PSEP provides recertification programs throughout Iowa and in FY17 trained 10,934 Commercial/Noncommercial/Public Pesticide Applicators and 14,468 Private Pesticide Applicators through Continuing Instruction Course (CIC) programs. In FY17, the PSEP directly contributed \$858,587,600 in economic impact in Iowa through these training programs, based on 2016 wage information from Iowa Workforce Development. In addition to recertification programs, the PSEP writes training manuals necessary for initial certification of both private and commercial pesticide applicators and other educational publications. In FY17 nearly 26,000 educational publications were distributed to the public, including pesticide applicator manuals, record keeping guides, pest issues, and other pesticide-related publications. The PSEP is also involved in other areas related to safety. One area includes revisions to the EPA Worker Protection Standard (WPS) regulation. Through the PSEP efforts, nearly 2000 individuals completed WPS training courses through ISU Extension and Outreach designed to protect those working around agricultural pesticides from potential exposure and to mitigate exposures that do occur.

**ISU Extension and Outreach Meat Science program** provides companies from the United States and around the world with cutting-edge education on meat processing and food safety technologies. In addition to offering workshops for small processors, training programs for some of the nation's largest processors also are developed and delivered.

During 2017, 22 workshops or short courses were held with a total attendance of 1,501 individuals, including 110 international attendees. Topics covered included regulation updates, Hazard Analysis Critical Control Point (HACCP) food safety workshops, and multi-level training sessions. These educational programs resulted in an economic impact in Iowa of approximately \$19 million in retained or increased sales, \$1.5 million in cost savings, \$4.5 million in increased investment, and 35 jobs created or retained.

**Crop Advantage Conferences.** ISU Extension and Outreach hosted 14 **Crop Advantage Conferences** across Iowa in January 2017; 1,960 farmers and agribusiness professionals attended. Participants could be categorized as 67 percent farmers, 27 percent agribusiness, and 6 percent other. The majority (55 percent) of the attendees farmed between 250 to 1,000 acres and 37 percent farmed more than 1,000 acres. One focus of the 2017 program was to increase farmer awareness of the impact of Palmer amaranth on crop production. Prior to 2012, Palmer amaranth had not been identified in Iowa. In 2016, the infestation of Palmer manifested due to contaminated seed used to plant Conservation Reserve Program pollinator habitat. As of June 2017, nearly half of Iowa counties had been positively identified for having Palmer amaranth. The major concern with this weed is its extremely aggressive growth that can limit soybean yields by up to 80 percent. Results from the 2017 Crop Advantage program showed 44 percent of Crop Advantage attendees participating in the Palmer amaranth sessions went from little or no understanding of how to identify this new pest prior to the meeting, to a moderate or better level for identifying Palmer amaranth. Results also showed that farmers increased their ability to develop an effective management program for Palmer amaranth. Participants show a definite recognition that they must scout and be vigilant in managing this weed before it spreads

**Integrated Crop Management Conference.** The Iowa State University Extension and Outreach **Integrated Crop Management conference** attracts roughly 900 participants annually from Iowa and across the Midwest. At the 2017 conference, 39 presentations were available to Iowa certified crop advisers, who were awarded 6,026 hours of continuing education credit. Of the 881 attendees in 2017, 111 responded to a survey. These respondents farmed or advised clients on 1.8 million acres of corn and soybeans in Iowa and estimated their profit increase was between \$5 and \$10 dollars per acre for a collective benefit of \$14 million to these operations.

**Nitrogen and Water Week.** In the summer of 2017, five events were held as part of **Nitrogen and Water Week**, hosted by ISU Extension and Outreach. The workshops, attended by 118, offered information about water quality research being conducted by Iowa State University, how water quality data is collected and how agronomic practices effect drainage water quality. By learning about and adopting in-field and edge-of-field management practices and methods for determining nitrogen application rates, farmers can maximize profitability and reduce nitrate loss to Iowa's water bodies.

**Iowa Drainage School.** Iowa State University Extension and Outreach initiated the **Iowa Drainage School** to educate stakeholders on sub-surface drainage concepts customized to the upper Midwestern states. Since 2007, 335 participants, consisting of contractors, engineers, drainage planners, landowners, farmers, agency staff, and drainage district supervisors, have attended the school. The school has been a collaborative effort of University of Missouri, University of Minnesota, and South Dakota State University, as well as USDA-NRCS, and various industry partners. Continued education on field drainage systems will help educate farmers and service providers about the impact water-logged areas have on crop yield. When a drainage system is properly designed and installed, farmers can benefit from improved corn yields from 120 to 150 bushels per acre. During the history of the Iowa Drainage School, 51,722 acres have benefitted from the farmers'

knowledge gained in the workshop. At a market price of \$3.00 per bushel for corn, \$1,551,660 of increased income has been realized.

**Iowa 4-H Youth Development** programs are headquartered at Iowa State University and available through ISU Extension and Outreach offices in all Iowa counties. (4-H is the youth program of America's Cooperative Extension Service and is the nation's largest youth development organization.) 4-H connects with almost 1 in 5 Iowa K-12 students to retain them as future young professionals in rural Iowa, improve their college and career readiness, provide them with service opportunities in their communities, and engage students affected by the achievement gap.

**4-H Youth Development addresses the STEM literacy gap;** Last year, 34,006 youth participated in STEM-related programming. The Iowa Governor's STEM Advisory Council has identified STEM-abled workers (skilled in science, technology, engineering, and math) as a critical component of the growth of Iowa's economy. In the "*Iowa's Re-Envisioned Economic Development Roadmap*," prepared by Battelle Technology Partnership Practice and released in December 2014, the creation of a K-20 industry-driven career development partnership with the education community was cited as critical. "To provide Iowa with a robust and predictable workforce pipeline in demand by Iowa businesses requires a systematic and pro-active industry-driven career development partnership with K-20 education. The partnership must focus on and improve upon the transitions of students into middle- and high-skill career opportunities through workplace learning from technical education and apprenticeships (for middle-skills jobs) to increased capacity of colleges and universities to provide career awareness, experiential learning and connections to Iowa employers (for high-skill jobs), as well as retraining opportunities for recent graduates who were not well-served in the past to gain the skills to compete for career opportunities."

**4-H has partnered with Iowa State University's Colleges of Business and Design** to emphasize STEM with a business development component. In partnership with the ISU College of Business, 4-H has developed a program called Cy's Pizza Pies, a business simulation program that introduces youth to business opportunities and entrepreneurship. The program has variations for grades 2 through 12 and sessions ranging from 45 minutes to ½ day. The program reached 40 youth in its second year.

Further advancing Iowa State's land-grant ideals and vision around science, technology and human creativity, more than 10,000 youth in the past year were exposed to the mobile **Forward Learning Experience bridging 21st Century Skills, STEM and creative problem solving.** Iowa 4-H youth and students saw and experienced first-hand emerging design technologies such as virtual reality, 3D digital and physical prototyping, and circuit bending. This provided 4-H youth and students in all corners of the state a vision of their future as 21st century citizens, positively impacting their communities and world around them using STEM skills and creative thinking. When asked, "Do you like *STEM MORE* than before," in initial program evaluations, the most common responses were "Quite a bit" and "A great deal." The Forward Learning Experience visited school classrooms, 4-H camps, STEM festivals, science nights, county fairs and maker fair events across Iowa, visiting 61 of Iowa's 99 counties.

**Human Sciences Extension and Outreach** provides research-based information and education to help families make decisions that improve and transform their lives. Specialists work with Iowa State's College of Human Sciences and in partnership with other organizations and agencies to meet the needs of Iowa families.

**Volunteer Income Tax Assistance (VITA).** The VITA program trains volunteers to provide free tax preparation to families with low or moderate incomes in their local community. Creating awareness of eligibility for the Earned Income Tax Credit (EITC) is an important part of the VITA program. The EITC enhances the lives of workers by augmenting wages. In turn, this flow of income may have a substantial economic impact in local communities, such as assisting small businesses, spurring local economic development, and strengthening neighborhoods. Special efforts were made to increase awareness of the VITA and EITC programs in rural Iowa. During the 2018 tax season, ISU Extension and Outreach worked with community partners to recruit and train 55 volunteers to provide free tax preparation services to local families through the VITA program. In 2018, VITA volunteers helped 1,369 Iowans complete their 2017 income tax returns. As a result, 396 filers in the 12 counties that participated in the ISU Extension and Outreach community partnerships qualified for the EITC and received a total of \$667,044.

**Human Sciences Extension and Outreach offers educational opportunities to strengthen Iowa's early childhood education workforce.** In Iowa, an estimated 171,552 children under the age of six are in childcare and preschool programs (Bureau of Labor Statistics, 2017). Currently in Iowa, there are an estimated 3,886 licensed childcare center programs and 4,533 registered childcare home programs, with revenue of \$447.6 million. However, about one-fourth of Iowans live in an area undersupplied with licensed or registered child care options. Within the last five years, there has been a 38% decline in available child care statewide (Iowa Child Care Resource & Referral, 2018).

**Reliable Childcare.** Iowa's families need reliable childcare to be able to work and contribute to Iowa's economy. However, childcare is labor intensive and expensive. The average cost of center-based infant child care in the United States, adjusted for inflation, exceeds 27 percent of median income for millennial families (Child Care Aware, 2017). Iowa families can expect to pay \$6,684 to \$13,085 annually per child. Despite high fees, Iowa childcare teacher and provider wages remain low. The annual mean full time wage is \$20,520, which falls within the lowest ranking of state median wages for childcare workers, significantly below 40 other states (Bureau of Labor Statistics, Occupational Employment Statistics, 2017). The challenges of low wages are compounded by a critical lack of health and retirement benefits. High turnover and reduced stability are the result. This instability also affects the quality of care and early childhood education for Iowa's young children and creates a continuously high demand for entry-level training.

During FY 2018,

- Human Sciences Extension and Outreach training programs included on-site and online learning experiences for entry-level and experienced early childhood professionals. The educational goals were to: (1) increase understanding and practice of research-based best practices to improve quality care and education for young children and (2) provide individuals with the skills and training they need to be successful and remain in the early childhood education field.
- **160,721** hours of educational programming were provided to **32,195** early care and education professionals.
- In post-training evaluations, **31,063** individuals (96% percent) reported or demonstrated new knowledge, skills, or program improvements. Evaluations show that teachers and caregivers significantly increased their understanding of child development, early learning, managing children's behavior, nutrition, and health and safety practices.



**Juntos Para Una Mejor Educación (Together for a Better Education).** ISU Extension and Outreach partnered with schools and community organizations, connecting 65 community volunteers, 233 Latino youth, and 237 Latino parents across 11 communities. The goal was to assist youth in graduating from high school and pursuing higher education.

- The pre/post evaluation data indicated that after participating in *Juntos Para Una Mejor Educación*, parents significantly increased their awareness of their youth's aspirations for their future and goals after high school, learned how to navigate the United States school system, and helped their youth access higher education. Youth significantly increased their awareness of what they needed to do in order to prepare for and increase their opportunities to go to college. Parents and youth significantly increased communication with school staff and with each other, and grew closer together as a family.
- The longitudinal data collected from 104 youth and 89 parents who participated in additional programmatic components revealed that among youth, self-efficacy increased, critical thinking increased, conduct problems decreased, and hope among parents increased. Through this effort, 57 youth visited college campuses and 13 youth enrolled in college.
- Further impacts may be found at: 1) JUNTOS: The Valenzuela Family Shares Their Story: <https://www.youtube.com/watch?v=uhLLXI9wc58> and 2) Join Juntos for a Better Education: <https://www.youtube.com/watch?v=gSNDIKHyZxg&t=24s>

**ServSafe®** . Human Sciences Extension and Outreach specialists have taught the **ServSafe® food safety certification** program for 25 years as registered instructors for the National Restaurant Association Educational Foundation's internationally recognized food safety certification program. ServSafe® is one of the programs approved to meet the Certified Food Protection Manager credential. Iowa's Food Code requires at least one supervisory employee in licensed foodservices be certified in food safety through an approved program. Human Sciences Extension and Outreach partners with the Iowa Restaurant Association to offer this training throughout the state. Participants have included those from commercial retail foodservices, such as restaurants, and institutional operations such as hospital and schools. A partnership with the Iowa Department of Human Services has supported attendance of childcare providers at these trainings, with close to 500 scholarships awarded over the last five years. In the last year, more than 2,000 Iowans participated in ServSafe® classes taught by Human Sciences Extension and Outreach, with 86 percent successfully earning the Certified Food Protection Manager credential. Ten classes in Spanish were offered at various locations around the state. Human Sciences Extension and Outreach serves Iowans by offering the ServSafe® program regularly throughout the state. Upcoming events and more information are available on the Food Safety web site ([www.iowafoodsafety.org](http://www.iowafoodsafety.org)) and <https://register.extension.iastate.edu/servsafe>.

**END OF YEAR REPORT: JULY 2018**  
**IOWA STATE UNIVERSITY RIF PROGRAM**

**EXECUTIVE SUMMARY**

**GIVF/RIF Commercialization Program**

The projects pair ISU faculty with Iowa companies to create or improve products or processes. One year after the completion of the project, the Iowa companies are surveyed for impact by the Center for Industrial Research and Service (CIRAS). These funds are a **critical source of gap funding**. They represent a unique resource that can be applied toward the success of Iowa companies. A summary of the projects funded to date is below, followed by the list of active projects. Since its inception, 151 projects have been funded through the Commercialization Program. One hundred forty three of these projects are complete and many show excellent progress in improving the competitiveness and profitability of the Iowa companies involved; for example, one industry partner reported \$20,000,000 in increased sales as a result of their involvement in an RIF project. Fifty three startup companies have been assisted, including **32 new companies that were started in the first eleven years as a direct result of the GIVF/RIF funding**. **Over the past 12 months, several of these startups have attracted significant private, state and federal funding, raising over \$3,000,000 in early stage investment to facilitate commercialization**. In total, **more than 100 Iowa companies have participated** in the program.

Surveys are conducted by CIRAS one year after project completion (Note: full impact takes a minimum of 5-10 years).

**Survey Results for FY07-08 through FY16-17 Projects**

Project Dates	Survey Year	Companies Surveyed	Jobs Created or Retained	Total Sales Increase or Sales Retained	Total Investment & Cost Savings	Average Impact per Company
FY07-08	FY09	9	18	\$3,700,000	\$2,760,000	\$720,000
FY08-09	FY10	8**	6	\$600,000	\$732,000	\$166,500
FY09–FY10+	FY11	7**	13	\$675,000	\$967,000	\$234,571
FY10-FY11	FY12	6**	6	\$1,750,000	\$1,730,000	\$580,000
FY11-FY12	FY13	12**	13	\$2,470,000	\$2,571,000	\$420,083
FY12-FY13	FY14	6**	21	\$750,000	\$1,315,000	\$344,167
FY13-FY14	FY15	2	3	N/A	\$1,167,000	\$583,500
FY14-FY15	FY16	5**	3	N/A	\$454,500	\$90,000
FY15-FY16	FY17	4*	4	N/A	\$1,120,000	\$280,000
FY16-FY17	FY18	9**	9	\$32,600,000+	\$2,440,750	\$3,893,417

\*\*Surveys were not completed for all projects (not everyone chooses to participate in the survey.). \*All surveyed companies were start-up companies. +The sales increase was primarily from 1 successful project, but the jobs impact was spread. Many companies indicated it was too early to tell the sales impact (this is a frequent comment through the years).

**Project Outcomes for FY09 through FY17\***

Year Project Completed	Number of Projects	Number of Publications & Presentations	Number of Invention Disclosures	Number of External Funding Applications	Number of Applications Awarded	External Funding Received*
FY18	16	12	2	16	7	\$1,375,000
FY17	9	12	8	9	4	\$450,000
FY16	15	10	3	18	5	\$1,070,000
FY15	14	12	2	3	2	\$384,999
FY14	7	19	1	16	4	\$370,000
FY13	4	6	2	12	5	\$795,000
FY12	11	50	4	12	6	\$6,364,000
FY11	11	46	3	20	6	\$940,000
FY10	14	99	6	47	13	\$2,720,000
FY09	15	53	4	48	20	\$3,500,000

\*A number of external funding applications were still pending at the time of reporting and not all award amounts were reported.

### Proof of Concept Initiative

The GIVF/RIF funds have been incorporated into a Proof of Concept Initiative (POCI)

<http://www.industry.iastate.edu/POCI.html>. The POCI is intended to build on the foundation started by the GIVF program, include additional funding sources such as i6, Plant Sciences, etc., and position Iowa State to more rapidly propel technologies toward market opportunities. We accomplish this by emphasizing both the business opportunity and the technology in projects that are funded through the POCI. By doing this we will position young companies to be able to attract the next stage of funding from either the state, angel or VC sources and/or position technologies to be more attractive commercialization opportunities for existing companies.

There were an additional 16 projects funded under the POCI, using non-GIVF/RIF funding sources. A grand-total of 167 projects have been funded through the POCI model from FY07 – FY18; note that i6 funding terminated on March 31, 2014, so future POCI projects will not include this funding source. Final reports for projects funded with i6 and Plant Sciences Institute funds were provided in the full year report for FY14. Summary statistics for all POCI projects (GIVF/RIF and all other funding sources) are as follows:

**Project Outcomes for FY09 through FY18<sup>†</sup>**

Year Project Completed	Number of Projects	Number of Publications & Presentations	Number of Invention Disclosures	Number of External Funding Applications	Number of Applications Awarded <sup>†</sup>	External Funding Received**
FY18	16	12	2	16	7	\$1,375,000
FY17	9	12	8	9	4	\$450,000
FY16	15	10	3	18	5	\$1,070,000
FY15	14	12	2	3	2	\$384,999
FY14	11	22	1	25	8	\$1,330,000
FY13	5	10	6	16	6	\$1,020,000
FY12	11	50	4	12	6	\$6,364,000
FY11	11	46	3	20	6	\$940,000
FY10	14	99	6	47	13	\$2,720,000
FY09	15	53	4	48	20	\$3,500,000

<sup>†</sup>Includes all projects funded through the POCI. \*\*A number of external funding applications were still pending at the time reports were submitted and some information on award amounts was not included.

Principal Investigator	FY17 RIF Projects (To finish May 31, 2018)	Award Amount
<b>Ratnesh Kumar</b>	In-Situ Wireless Soil Moisture and Salinity Sensor and Extension for Nitrate and Other Nutrients/Ion Sensing—Phase II	\$50,000
<b>Keith Vorst</b>	Technology for Real-Time Detection of Contamination in Food Processing Systems and Packaging for Value-added, Waste-Stream Diversion—Phase II	\$50,000
<b>Wenyu Huang</b>	Co-Production of High-Value Chemicals with “Drop-in” Biofuels from Lignocellulosic Biomass Using a Novel Liquid-phase Refinery Process—Phase II	\$50,000
<b>Eric Cochran</b>	Safe and Convenient Chemical Purification System	\$50,000
<b>Martin Thuo</b>	Metal Separation for Recovering Rare-earth and Specialty Metals from Electronics Waste	\$50,000
<b>Sri Sritharan</b>	Design Certification of Hexcrete Wind Turbine Tower Cells	\$25,000

<b>Manjit Misra</b>	A Non-Vertical Dynamic Flow Sensing Technology for Bulk Materials	\$23,550
<b>Chris Tuggle</b>	Development of a Commercial System to Produce and Deliver the SCID Pig, a Biomedically Important Animal Model	\$21,466
<b>Principal Investigator</b>	<b>FY18 RIF Projects (To finish May 31, 2018)</b>	<b>Award Amount</b>
<b>Chao Hu</b>	Predictive Modeling with Automated Analytics for Intelligent Bearing Prognostics	\$50,000
<b>Jean-Philippe Tessonier</b>	Polyamides with Bio-Enabled Properties	\$50,000
<b>Zengyi Shao</b>	Building a Novel Microbial Manufacturing Platform for de novo Synthesis of High-value Nutraceuticals	\$50,000
<b>Ludovico Cademartiri</b>	Preparation of ultra-flat metal surfaces by mechanical polishing and/or surface reconstruction	\$50,000
<b>Baskar Ganapathysubramanian</b>	Exploring 3D Imaging Technologies for Field Phenotyping	\$50,000
<b>Steve Carlson</b>	Identification of a Non-antibiotic Drug that Prevents BRD at the Feedlot	\$50,000
<b>Jonathan Claussen</b>	Rapid Salmonella Detection in Food Processing Facilities	\$50,000
<b>David Laird</b>	Development of Field Mobile Soil Nitrate Sensor Technology to Facilitate Precision Fertilizer Management	\$49,700
<b>Ursula Frei</b>	Evaluation of Spontaneous Genome Doubling Ability in Haploids of Diverse Genetic Background	\$28,689
<b>Principal Investigator</b>	<b>FY18 RIF Projects (To finish December 31, 2018)</b>	<b>Award Amount</b>
<b>Chris Tuggle</b>	Development of a Commercial System to Produce and Deliver the SCID Pig, a Biomedically Important Animal Model	\$9,997

## RIF FUNDING: PROGRESS REPORT

**Report Type:** Final

**Title:** In-Situ Wireless Soil Moisture and Salinity Sensor and Extension for Nitrate and other Nutrients/Ion Sensing (Phase I and Phase II)

**PIs:** Ratnesh Kumar and Liang Dong

**Company Partners (if applicable, company names only):** Microwaves by the Weber, Inc.

**Project Goal:** Research and Technology Transfer Efforts towards In-Situ Wireless Soil Moisture and Salinity Sensor, and extension for Nitrate Sensing

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**Publications/presentations based on project:** Several industry presentations have been made to Solum/Climate Corporation/Monsanto, John Deere, Pionner, Raven Industries, TechAccel, IntelliFarm; the work was also presented at the conferences and journal articles:

1. Energy Harvesting and Storage, 2015, Santa Clara, "In-Situ, Sensor-Aided Sustainable Agriculture and Broadband Vibrational Energy Harvesting"
2. S. Tabassum, Q. Wang, W. Wang, S. Oren, M. A. Ali, R. Kumar, and L. Dong, "Plasmonic Crystal Gas Sensor Incorporating Graphene Oxide for Detection of Volatile Organic Compounds", IEEE International Conference on Micro Electro Mechanical Systems (MEMS), Shanghai, China, Jan. 2016.
3. M. A. Ali, H. Jiang, N. K. Mahal, R. J. Weber, R. Kumar, M. Castellano, "Microfluidic Impedimetric Sensor for Soil Nitrate Detection Using Graphene Oxide and Conductive Nanofibers Enabled Sensing Interface", Sensors & Actuators: B. Chemical, Volume 239, February 2017, Pages 1289–1299.
4. S. Tabassum, Y. Wang, J. Qu, Q. Wang, S. Oren, R. J. Weber, M. Lu, R. Kumar, and L. Dong, "Patterning of nanophotonic structures at optical fiber tip for refractive index sensing", 2016 IEEE Sensors Conference, Orlando, FL, Oct. 2016.
5. Z. Xu, X. Wang, R. J. Weber, R. Kumar, and L. Dong, "Microfluidic Electrophoretic Ion Nutrient Sensor", 2016 IEEE Sensors Conference, Orlando, FL, Oct. 2016.
6. M. A. Ali, S. Tabassum, Q. Wang, Y. Wang, R. Kumar and L. Dong, "Plasmonic-Electrochemical Dual Modality Microfluidic Sensor for Cancer Biomarker Detection", 2017 IEEE MEMS Conference, Las Vegas, Jan. 2017.
7. Z. Xu, X. Wang, R. J. Weber, R. Kumar, and L. Dong, "In-Situ Soil Nutrient Detection Using Chip Scale Electrophoresis", IEEE Sensors Journal, pages 4330-4339, 14(17), 2017.
8. S. Tabassum, R. Kumar, and L. Dong, "Nanopatterned Optical Fiber Tip for Guided Mode Resonance and Application to Gas Sensing", IEEE Sensors Journal, pages 7262-7272, 17(22), 2017.
9. S. Tabassum, R. Kumar, and L. Dong, "Plasmonic Crystal based Gas Sensor towards an Optical Nose Design", IEEE Sensors Journal, pages 6210-6223, 17(19), 2017.
10. K. Singh, M. Juetten, R. Weber, and R. Kumar, "A Bistable Vibration Energy Harvester with Synchronized Extraction and Improved Broadband Operation through Self-Propelled Feedback" TechConnect, May 2017, Washington DC.

**Invention disclosures:** Four invention disclosure and patents have been filed on

1. ISURF 04183: Soil moisture and salinity sensor with its wireless interface---Patent filed, May 2015.
2. ISURF 04354: Vibrational Energy Harvesting using Bistable Piezoelectric Cantelever---Patent filed, July 2016.
3. ISURF 04453: Nano-patterning on Fiber Tip for gaseous/aqueous species detection---Patent filed, Oct. 2017.
4. ISURF 04454: Soil Nutrient Sensing---Patent filed, Oct. 2017.

The invention 4183 and 4454 have been **licensed by Raven Industries**. The invention 4453 has been licensed by **Ingenious Ag**.

**External funding applied for (indicate received/denied/pending):**

1. **One NSF funding received, April 2016-Oct. 2017**, "PFI: AIR - TT: In-Situ Wireless Soil Sensor for Moisture, Salinity and Ions", \$200K.
  2. **NSF proposal submitted, March 2016, (not funded)**, "NSF, INFEWS/T3: Reducing Energy Demand and Water Discharge Pollutants in Agriculture Food Production: Sensors, Models and Socio-Economics", Aug. 16, 2016-Aug. 15, 2020, in amount of \$3M.
  3. **NSF proposal submitted, March 2017 (not funded)**, "NSF, INFEWS/T3: Reducing Energy Demand and Water Discharge Pollutants in Agriculture Food Production: Sensors and Models", Aug. 16, 2017-Aug. 15, 2021, in amount of \$2.35M.
  4. **Gift from Texas Instruments, August 2017**, For research on impedance spectroscopy for soil ion separation, \$50K.
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**Progress report (300 word maximum, please focus on results in non-technical terms and commercialization progress):** The research work on In-Situ Soil Moisture and Salinity Sensing and its Wireless Interface was completed prior to RIF funding. Subsequent to RIF funding, we have been engaged in its prototyping and technology transfer efforts. A new version of the sensor was prototyped that corrected the hardware and software bugs. A demo to Raven Industries was presented on ISU campus in Sept. 2015. Raven invited us back for another demo at their site in Sioux Falls, SD in Nov. 2015. In Spring 2016, Raven licensed our soil moisture sensor technology.

Following the licensing, Raven visited us in Fall 2016 when we gave them an updated demo, and also presented the work on soil nutrient sensing and plant gas sensing. We then provided the hardware and software designs of the soil moisture sensor to Raven, who has assembled a prototype at their end, and now getting ready to test the design. We shipped them an updated software in Sept. 2017---This allows data collection in one go (the earlier version required doing this in 4 iterations), and also corrected some errors in mapping the short-open-matched-load measurements to the corresponding pin-assignments. Our Phd student, Bhuwan Kashyap, supported by RIF, is interfacing with Raven to help complete the know-how and technology transfer.

Our impedance spectroscopy approach to soil moisture and salinity sensing was discovered by **Texas Instruments** in their on-line search. They invited us for a discussion, as they want to see it applied in a non-agricultural domain, namely, for measuring fluid level in automobiles. To investigate this, TI offered a summer internship in Summer 2017 to Bhuwan Kashyap at their Kilby Lab in Dallas. Also to continue the research in Fall 2017, TI has provided us an unrestricted gift of \$50K. This is especially encouraging since TI can be valued partner for our sensors related work, where we are using TI's processor-cum-transceiver.

The development work on soil Nitrate sensor is also progressing, and is led by the Phd student Zhen Xu. A paper based on this work was presented at the IEEE Sensors Conference in Oct 2016, and later a journal version was published in IEEE Sensors Journal in May 2017. We have completed the design and testing of the sensing unit which can analyze a soil solution sample to measure the concentrations of various ions, including nitrate. The results have been encouraging---we were successful in separating multiple different ions in a given soil sample. To see the working of the nutrient sensor and optical gas sensor (see below), Raven visited us on Jan 9 2017, where we demonstrated the nutrient and the gas sensor. We presented another update to Raven on May 4, 2014. Subsequent to this, Raven made a decision to move forward with licensing our nutrient sensor, and an option licensing agreement went into place in Sept. 2017. Continuing on our work, we also designed and tested the microfluidic system which can autonomously extract the soil solution from soil. Since then, the work to integrate the sensing and solution extraction units is ongoing. Some progress on integration work has been made, and more needs to be done. Raven visited us again in Nov. 2017 where we gave them a demo of the integrated sensor, packaged in a portable case. Later in the same month, we also provided Raven a full technology description, listing all components, their layouts, hardware details, software code, assembly and operating instructions. It is also planned that a prototype sensor will be assembled and sent to Raven.

We are also working on developing a sensor for the detection of gaseous molecules excreted by plants under biotic and abiotic stresses. This work is being done by a 3<sup>rd</sup> Phd student, Shawana Tabassum. We have developed a method to be able to etch a nano-pattern on the tip of an optical fiber that can interact with the gas species of interest, and provide a response in form of a change in its transmitted and/or reflected spectrum. The work is currently in its design and development phase, and upon which prototyping will follow. The work was disclosed under ISURF 04453, and a full patent on it was filed on Oct. 2017. In Oct. 2017, this technology got licensed by a start-up, Ingeneious Ag.

During this period, we also signed NDAs with Pioneer, TechAccel and IntelliFarm, and made presentations in Oct 2015, March 2016 and April 2016, respectively. We also attended TechConnect 2017 in May 2017 in Washington DC, where we published our work on energy harvesting (4354). Had an opportunity to a few industries, including 3M from St. Paul-Minneapolis location. Subsequent to this, I attended NSF-IIP Grantees workshop, in June 5-7 in Atalanta, GA, where I presented a poster on our nutrient sensor. There I made a number of contacts with industries, importantly, Cargill and a few others (Atacama, Rassini, Propel[x]), and also the NSF-SBIR program managers.

## RIF FUNDING: PROGRESS REPORT

**Report Type:** Final Report

**Title:** Technology for Value-Add Recycled Plastics and Real-Time Detection of Contamination in Food Packaging and Waste-Stream Diversion

**PIs:** Keith Vorst and Greg Curtzwiler

**Company Partners (if applicable, company names only):**

Amcor Rigids  
Dart  
Peninsula Packaging  
Niagara Bottling  
IdeoPak  
American Packaging Company  
Johnsonville Sausage Co.

**Project Goal:** To define methods and systems for optimizing recycled plastics packaging substrates to provide value-add features and increase shelf-life of perishable products through real-time data capture during manufacturing and packaging operations.

**Publications/presentations based on project:**

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**Speaker/Presenter**

K. Vorst. 2016. Innovations in Recycled Plastics Packaging Technology. REFOCUS Recycling Summit for Society of Plastics Industries (SPI). Orlando, FL. April 26-27.

**Speaker/Presenter**

K. Vorst. 2016. Real-Time Detection of Organic and Inorganic Contamination in Packaging. 6<sup>th</sup> International Symposium on Food Packaging-Supporting Safety and Innovation, International Life Science Institute (ILSI). Barcelona, Spain Nov 16-18.

**Publications:**

- Curtzwiler, Greg W., Williams, Eric B., Maples, Austin L., Davis, Nathan W., Bahns, Ted L., De Leon, J. Eliseo., Vorst, Keith L. Ultraviolet protection of recycled polyethylene terephthalate. J. Appl. Polym. Sci. 134 (2017) 45181.
- Monge-Brenes, Ana-Lorena, Curtzwiler, Greg W., Vorst, Keith. Vitamin K1 and beta-carotene retention in fresh cut Arugula when packaged in post-consumer recycled polymer packaging. In Preparation.
- Curtzwiler, Greg W., Williams, Eric B, Hurban, Emily., Green, Joseph., Vorst Keith. Influence of post-consumer recycled content on extruded polyethylene film properties. In Preparation.

**External Funding:**

- 2017 Proof of concept for test markets. Determination of shelf-life and destructive degradation wavelengths in sausage packaging. Funded by the Johnsonville Sausage Co.
- 2016 INFEWS/T3: Enabling Innovative Systems Solutions with High Voltage Atmospheric Cold Plasma at the Intersection of Food, Energy, and Water, (National Science Foundation (NSF) Proposal number 1639054 \$2,168,720.00 (not reviewed). Note: Includes a large component on monitoring packaging contamination, removal or organic and inorganic compounds to add value to plastics.
- 2015-2016 Online Contamination Analysis of RPET During Forming Processes and Shelf-life Extension of Fresh-Cut Produce. Funded –Iowa State University Polymer and Food Protection Consortium (funded).

**Invention disclosures:**

Application Number 62/324,790; ISURF# 04335: Atty. Docket. No 29609.0740 Method for Optimizing Plastics Compositions Used in Packaging to Increase Shelf-Life of Perishable Products and System Thereof

**1.) Publication Number US 20140332994 A1 Detection in Thermoplastics (Danes and Vorst)**

International Application Number PCT/CL2014/000020

**Progress report (300 word maximum, please focus on results in non-technical terms and commercialization progress):**

This work has shown commercial viability of real-time analysis during plastic conversion is correlated to PCR content, compound identification and thus, shelf-life extension. The results from thermo-mechanical processing of

polyethylene terephthalate and high density polyethylene, which is known to cause a variety of degradation reactions in the polymer, produced a multitude of degradation byproducts/molecular structure rearrangement that reflect or absorb UV light and can be controlled through blending, additives and monitoring during conversion. Work completed at ISU mounted with in-line sensors (UV-Vis, IR, X-ray, fluorescence), with room for three more optical sensors (i.e.- Raman, NIR, etc.) demonstrated optimized blends and compounds for increased material performance. The current system has successfully collected full UV-Vis scans from 200-800 nanometers at a speed that can match industry standard extrusion rates. This data will be processed using an algorithm that combines data from the aforementioned sensors to predict PCR content and extend shelf-life by utilizing additives and compounds not visible to the human eye but capable of blocking specific electromagnetic wavelengths that cause degradation to food products.

Blends of polyethylene terephthalate and high density polyethylene containing known amounts of post-consumer recycled material (PCR) were run through several sensor array configurations such as inline UV-Visible light spectrometer (UV-Vis) and energy dispersive x-ray fluorescence (ED-XRF) and infrared (IR). Each sensor collected unique data signals which identifies various classes of chemical compounds and heavy metals present in the polymer matrix. Proof of concept work was performed in the Iowa State University Packaging Lab in conjunction with a commercial extrusion monitoring system and has demonstrated the potential integration into existing packaging manufacturing systems. Corporate partners have been engaged to facilitate installation of the beta system on commercial extrusion and packaging lines to demonstrate scalability and reliability of the system in real-world applications (Table 1).

**Table 1. Task Progress**

<b>Objective</b>	<b>Task</b>	<b>Milestone or Type</b>	<b>Milestone Verification</b>	<b>Anticipated Date</b>
1	Manufacturing trial for produce and light sensitive packaging	Milestone	Validation of shelf-life extension and reduced nutrient decay in bottles juices and salad kits	Completed
2	Cost analysis of feedstock, and thermoform container monitoring	Milestone	Develop cost models with ISU/IdeoPak for licensing	Completed
3	Develop marketing and promotional material using CyBiz	Milestone	Presentation ready models with product categories for strategic partners	Started May 2017
4	Product line identification and field of use for partners companies	Go/No Go	Identify field of use to exercise patent license	Completed with Johnsonville Sausage Co.
5	Roll out product to select markets	Go/No Go	Product claims validated and used in end markets with strategic partners	License Agreement to Develop product line



## RIF FUNDING: PROGRESS REPORT

**Report Type:** Final

**Title:** Co-production of Higher-value Chemicals with “Drop-in” Biofuels from Animal Manure Using a Novel Liquid-phase Refinery Process (Phase II)

**PI(s):** Wenyu Huang; Danny Anderson

**Company Partners (if applicable, company names only):** Esstar Bio Technology, LLC

**Project Goal:** The goal of this project is to demonstrate the technical feasibility of a two-step biomass conversion process, and the economic feasibility of co-production of high-value chemicals and “drop-in” biofuels from animal manure.

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**Publications/presentations based on project:** One presentation was given to a group of surface scientists in Ames Lab with the focus on structure-catalytic property relationship of the catalysts. Two presentations were given in BASF (03/15/16) and ExxonMobil (3/16/16) to attract industrial interests. Private presentations were given during conferences for potential collaborations.

**Invention disclosures:** Plan to file one application based on the conversion of the levulinic acid to  $\beta$ -acetylacrylic acid through a novel catalytic process.  $\beta$ -acetylacrylic acid is a high-value chemical that sales at \$20~100/gram currently. We also plan to file another patent on this novel manure processing technology.

**External funding applied for (indicate received/denied/pending):**

We applied for six SBIR/STTR grants so far. One of them is pending. Five of them were rejected. We did not apply for USDA and DOE proposal because there is no suitable topic in this round.

NSF, STTR (Pending)

Funding period: 07/01/2018 – 06/30/2019.

Total Award Amount: \$225,000. Huang group award: \$135,000 (includes overhead).

*“STTR Phase I: Co-Production of Value-Added Chemicals and NPK Fertilizers from Animal Manure”*

Wenyu Huang, co-PI (subcontractor); Esstar Bio Technology LLC, PI.

DOE, STTR (Rejected)

Funding period: 02/22/2017 – 02/21/2018.

Total Award Amount: \$150,000. Huang group award: \$90,000 (includes overhead).

*“Co-Production of Value-Added Chemicals and NPK Fertilizers from Animal Manure”*

Wenyu Huang, co-PI (subcontractor); Daniel Andersen, co-PI (subcontractor); Esstar Bio Technology LLC, PI.

NSF, STTR (Rejected)

Funding period: 07/01/2017 – 06/30/2018.

Total Award Amount: \$225,000. Huang group award: \$131,499 (includes overhead).

*“Cost-Efficient Production of Medium-Chain Chemicals from Animal Manure”*

Wenyu Huang, co-PI (subcontractor); Daniel Andersen, co-PI (subcontractor); Esstar Bio Technology LLC, PI.

NSF, STTR (Rejected)

Funding period: 07/01/2017 – 06/30/2018.

Total Award Amount: \$225,000. Huang group award: \$131,499 (includes overhead).

*“Cost-Efficient Production of Medium-Chain Chemicals from Animal Manure”*

Wenyu Huang, co-PI (subcontractor); Daniel Andersen, co-PI (subcontractor); Esstar Bio Technology LLC, PI.

DOE, STTR (Rejected)

Funding period: 02/22/2016 – 08/31/2016.

Total Award Amount: \$90,000 (includes overhead).

*“Catalytic Transformation of Cellulosic Waste Streams to Dicarboxylic Acids and Diols”*

Wenyu Huang, PI (subcontractor); Esstar Bio Technology LLC, PI.

[Type here]

USDA, SBIR (Rejected)

Funding period: 06/01/2016 – 01/31/2017.

Total Award Amount: \$33,000 (includes overhead).

*“A Novel Liquid Phase Refinery Process for the Conversion of Agricultural Biomass to “Drop-in” Biofuels”*

Wenyu Huang, PI (subcontractor); Esstar Bio Technology LLC, PI.

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**Progress report (300 word maximum, please focus on results in non-technical terms and commercialization progress):**

During Phase II of this project, we successfully achieved all milestones. Huang group successfully converted a variety of raw animal manure samples from pork, chicken, and beef to the value-added product—levulinic acid (LA). We successfully obtained good yields of LA from these waste feedstocks (0.006-0.016 ton of LA per ton of manure). Using a market price of LA (\$6300/ton), we estimate the sales of LA will solely contribute approximately \$38-100 additional revenue per ton of animal manure.

Meanwhile, Andersen group analyzed nutrients distribution in the products. We found that liquid product mainly includes nitrogen and potassium nutrients (very little phosphorous), while solid product mainly includes phosphorous. The separation of nitrogen and phosphorous nutrients are desired because excessive phosphorous nutrient has been put into lands, therefore needs to be removed. This technology will provide an effective way to generate nitrogen-rich and phosphorus-rich compost products for various fertilizer applications. Currently, the farmers ask for \$15 per ton of manure taken away from animal farms. Our technology produces LA (\$38-100) and nutrient-rich composts (~\$15), suggesting the process is highly likely to be profitable.

In collaboration with CyBIZ Lab, we conducted more techno-economic analysis. We found that the production scale will significantly impact the Minimum Selling Price (MSP) of LA. The MSP value of LA linearly decreases at <400 ton/day processing scale, while keeps relatively stable in the range of larger scale. We estimate an MSP of LA at \$719 per ton from 400 ton/day processing capacity facility, which is remarkably less than the current market price (\$6300/ton), confirming that the manure processing utilizing this technology will be potentially profitable.

To prepare the newly submitted NSF STTR proposal and address reviewers' comments, the Huang group established a collaboration with Prof. Dennis R Vigil in Department of Chemical and Biological Engineering. We also designed a process flow diagram (PFD) of this technology, which should address many comments received for our last submission.

## RIF FUNDING: PROGRESS REPORT

**Report Type:** Final

**Title:** Safe and Convenient Chemical Purification System

**PIs:** Eric Cochran,

**Company Partners (if applicable, company names only):** Polymer Advantage, LLC

**Project Goal:**

Develop an innovative chemical purification system for laboratory scale research that is safe, fast, economical, standalone and portable.

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**Publications/presentations based on project:** None

**Invention disclosures:** ISURF 04287

**External funding applied for (indicate received/denied/pending):** Partnerships for Innovation: Accelerating Innovation Research - Technology Translation (PFI: AIR-TT) internal proposal submitted.

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**Progress report (300 word maximum, please focus on results in non-technical terms and commercialization progress):**

Our research team at ISU, in collaboration with Polymer Advantage, LLC, applied for NSF SBIR funding for 2017. We received some good comments and suggestions from the reviewers, however the project was not chosen to be funded. We will apply again for 2018 NSF SBIR funding. During the semester, two undergraduate students were hired to complete the computer aided design of the purification apparatus. This included the replacement of our current and not so user-friendly column system with an innovative and easy to use/install system (columns and chemical refilling system). The design was completed and we will now start the assembly of the prototype purification system. This requires us to fabricate custom parts, purchase already made parts, *i.e. control panels columns, tubing, column packaging etc.*, and assemble the system. After this has been completed, we will start field trials.

In the last five months, our team has fabricated packing columns and chemical reservoir tank based on the designs made during last semester. The packing columns have design improvements based on quick connects and 3-way valves that make replacing/changing the columns easy while maintaining the system inert, this was one of the aspects in making the system user friendly and safe. The reservoir tank's design improvements include ease of refilling and safe input of chemical into the tank. The tank also has safety features that will work against any unforeseen pressure build up in the tank. In addition, our team has conducted stability measurements on the packing used in the columns. A diene chemical, isoprene was used to conduct these experiments and was found that at a loading of 200 ppm of inhibitor (usual supplier specification at 98% purity), the system can purify close to 800 L of chemical before it has to be reactivated/replaced. The purity of the chemical adhered to the rigorous exacting standard needed to carry out an anionic reaction to produce nearly monodisperse poly(isoprene) with targeted molecular weight. Our team used NMR analysis to show removal of moisture and inhibitor in the purified chemical. Our team is submitted an internal proposal for PFI-AIR TT grant that will help in fast tracking the commercialization of this technology.

## RIF FUNDING: PROGRESS REPORT

**Report Type:** Final

**Title:** Metal Separation for Recovering Rare-Earth and Specialty Metals from Electronics Waste

**PIs:** Martin Thuo

**Company Partners (if applicable, company names only):** Sep-All, LLC

**Project Goal:** Scale the processing capability with increase in purity of the separated materials.

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### **Publications/presentations based on project:**

"Dumpsites as 21st century mines: Affordable recovery rare-earths and critical materials from e-waste" 2017 ACS Sustainable Chemistry & Engineering Lectureship Awards: Symposium in Honor of Jinlong Gong, San Francisco, CA April 2-6 2017 (invited talk)

### **Invention disclosures:**

#### **External funding applied for (indicate received/denied/pending):**

Sep-All PI, C. Frankiewicz, with Prof. Martin Thuo: NSF SBIR Phase I – Denied

Sep-All PI, C. Frankiewicz, with Prof. Martin Thuo: NSF SBIR Phase I – Denied

Sep-All PI, C. Frankiewicz: Iowa Economic Development Authority, POCR – Received (\$25,000)

Sep-All PI, C. Frankiewicz: DOE-SBIR – Received (\$150,000)

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### **Progress report (300 word maximum, please focus on results in non-technical terms and commercialization progress):**

Sep-All has developed a process for the recovery of critical materials (rare-earths, precious metals) from electronic wastes.

#### **Project Milestones:**

1. Sep-all scaled the processing from a few mg per hour to 150 g per hour processing scale and optimized the processing conditions to allow rapid separation times ranging from 0.5-3 hrs.
2. Depending on the native composition, the purity of obtained materials ranged from 60-100 %. The yield of the process has been increased from a few particles to a few percent in the case of rare-earth materials (neodymium magnet wastes) and up to 80% in the case of gold from molecular electronic wastes.
3. Developed a pre-processing procedure towards the integration of industrial electronic wastes. Received and tested the process with hard drive wastes containing neodymium magnets and high-quality motherboards containing gold and silver.
4. For the no-cost extension, the PI and his group helped characterize some of the products derived from the work. Based on this analysis, a journal manuscript is in preparation for publication and industry partner has developed samples for beta-users based on the data generated by the ISU partner.

#### **Business Milestones**

1. A business canvas and pitch deck (presentation) has been prepared with the help of the ISU startup factory. The business model and path to profitability has also been modelled to allow for better projection of rate of growth of the business
2. Sep-All has completed the ISU startup factory program and has worked with CyBiz lab at ISU to continue the customer discovery process, especially for a new proprietary product that has emerged from the scaling process. For the separation process, customer discovery has been concluded and various partners and potential customers have been contacted. Three new potential customers have been approached and two MTA and NDA are being discussed to allow for further development of the process.
3. Sep-All has partnered with City of Ames Resource Recovery Facility and Scott County Electronics Demanufacturing Facility for a steady supply stream of electronics and metallic wastes.
4. Sep-All has contacted and is currently in discussion with two potential investors to close a see round of private investment.

Sep-All has submitted 2 SBIR/STTR grant proposals with its partners to strengthen the collaboration and ensure funding sources for continuous technology development.

5. An SBIR grant was submitted and awarded by the DOE.

## RIF FUNDING: PROGRESS REPORT

**Report Type:** Final

**Title:** Design Certification of Hexcrete Wind Turbine Tower Cells

**PIs:** Sri Sritharan

**Company Partners (if applicable, company names only):** Barr Engineering; HZ Windpower Iowa

**Project Goal:** To complete design certification of Hexcrete tower technology

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**Publications/presentations based on project:** None

**Invention disclosures:**

**External funding applied for (indicate received/denied/pending):** No funding has been received, but a preproposal to Iowa Energy Center has been submitted. In addition, a concept paper to build a test bed using the Hexcrete technology for the Southeast has been submitted and received positive feedback from potential sponsors. This effort will rely on public-private partnership for funding. A verbal commitment to build the first Hexcrete prototype in Iowa has also been reached.

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**Progress report (300 word maximum, please focus on results in non-technical terms and commercialization progress):** This project focuses on completing design certification on patented technology for building innovative, taller wind turbine towers using the Hexcrete Technology. TUV-SUD in Munich, Germany, was chosen for certification purposes because of their experience with certifying concrete towers including one built in Iowa.

Since December 2017, we have completed the following:

1. Based on the feedback, revised and resubmitted the design calculations and detailed drawings of a 20-m segment of Hexcrete technology suitable for use in building a 100 m tall wind turbine towers to TUV-SUD.
2. Finalized details for a door panel and a transition ring beam required to be placed between the Hexcrete tower and steel tubular shell for hybrid towers. This is being currently reviewed.
3. Preliminary design of a 40 m Hexcrete segment is being done for the new loads corresponding to a prototype tower in Iowa. This will be a hybrid tower with a hub height in the 120-135 m range.
4. Contributed to the design of a foundation led by BARR, including details for post-tensioning anchorage and entry way to underneath the columns for prestressing purposes.

## RIF FUNDING: PROGRESS REPORT

**Report Type:** Final

**Title:** A Non-Vertical Dynamic Flow Sensing Technology for Bulk Materials

**PIs:** Manjit Misra, Yuh-Yuan Shyy

**Company Partners:** FloMetrix

**Project Goal:** Design, fabricate and conduct proof-of-concept testing for a Non-Vertical Dynamic Flow Sensing (NVDFS) technology.

**Publications/presentations based on project:** None

**Invention disclosures:** None

**External funding applied for (indicate received/denied/pending):**

NSF SBIR (pending)

**Progress report (300 word maximum, please focus on results in non-technical terms and commercialization progress):**

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In phase I, we conducted four tasks.

**Task 1: Design and Fabricate a laboratory-scale NVDFS sensor:** Materials flowing non-vertically *slide* along the bottom of a spout or a conduit as opposed to falling freely in a vertical flow. Therefore, we developed a sensor so that the sliding materials travel over a sensing surface and exert pressure on the sensing surface. Initial tests for flowability were conducted with three crops (soybeans, rice and corn) and four different angles (30, 40, 50, and 60 degrees). The sensor maintained the flowability of the products without retarding the flow.

**Task 2: Integrate the sensor with signal conditioning device and build a laboratory prototype:** The sensor was integrated with a signal acquisition device and the output signal was conditioned. A software was developed to analyze and calibrate the signal with the weight of the product flowing over surfaces by correlating the signal to the flow. The weight output was displayed in real time.

**Task 3: Conduct tests to evaluate the performance using different materials and degrees of flow incline:** The laboratory prototype was tested with two materials (soybeans and corn) and at various degrees of incline for low flow rate (75-300 bph). The results of a typical test is shown over 99% accuracy for soybeans.

**Task 4: Conduct tests at the company R&D facility in Ames using higher flow rates:** We are currently conducting tests for accuracy at higher flow rates (200-650 bph). The results are very promising as evidenced by the high degree of correlation of the flow rate predicted by the PLC with the real flow measurement (see a typical test result shown in the figure below) and feel the technology is ready for testing in the real world leading to commercialization in precision agriculture, industrial and pharmaceutical operations.

## RIF FUNDING: PROGRESS REPORT

**Report Type:** Final

**Title:** Development of a Commercial System to Produce and Deliver the SCID Pig, a Biomedically Important Animal Model

**PIs:** Chris Tuggle

**Company Partners (if applicable, company names only):** Struve Labs International

**Project Goal:**

This project will establish that Struve Labs can supply this important animal model, through testing three steps as described in more detail below; farrowing the pigs into a clean facility, rearing them and transporting them in a special transport vehicle. If successful, this will establish an Iowa company as a supplier of this unique biomedical model.

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**Publications/presentations based on project:** N/A

**Invention disclosures:** N/A

**External funding applied for (indicate received/denied/pending):** N/A

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**Progress report (300 word maximum, please focus on results in non-technical terms and commercialization progress):**

We have completed the delivery and farrowing of one litter to Struve. The litter was C-sectioned and grown to ~5 weeks of age, delivered back to ISU and successfully shown to be free of teste pathogens. This work successfully shows the company can perform the major components of the work required. Unfortunately, none of the pigs in the first litter were SCID. However, there were no problems with any aspect of the process, so we believe that no technical issues remain.

We have already set up to start litters in late December for delivery of a pregnant sow to Struve to repeat this process. We are performing artificial insemination on 3 carriers, and expect that at least one will be pregnant so we can repeat the process above in April-May 2018. This will complete the project as originally proposed by June 2018.

A report on the January-May 2018 reporting period was not provided for this project.

## RIF FUNDING: PROGRESS REPORT

**Report Type:** Final

**Title:** Predictive Modeling with Automated Analytics for Intelligent Bearing Prognostics

**PIs:** Chao Hu

**Company Partners (if applicable, company names only):** Vermeer Corporation

**Project Goal:** The goal of this project is to develop an intelligent prognostics platform for just-in-time maintenance of bearings. The platform will fully integrate vibration sensing, data acquisition, signal processing, and predictive analytics, and can be used to detect, diagnose, and prognose bearing failures for agricultural and construction equipment, wind turbines, and other industrial equipment (e.g., gearboxes, drive shafts, suspension).

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**Publications/presentations based on project:** Two conference papers [1,2] have been submitted and one journal paper has been prepared and is ready for submission.

[1] Sadoughi M., and Hu C., "A Physics-based Deep Learning Approach for Fault Diagnosis of Rotating Machinery," Submitted, *44<sup>th</sup> Annual Conference of the IEEE Industrial Electronics Society*, Oct 21-23 2018, Washington, DC.

[2] Sadoughi M., Downey A., Bunge G., Ranawat A., Hu C., and Laflamme S., "A Deep Learning-Based Approach for Fault Diagnosis of Roller Element Bearings," Submitted, *Annual Conference of the Prognostics and Health Management (PHM) Society 2018*, Oct 24-27 2018, Philadelphia, PA.

**Invention disclosures:** None as of May 31, 2018

**External funding applied for (indicate received/denied/pending):** The PI has applied for an external funding from the National Science Foundation (NSF) Cyber-Physical Systems Program on the topic of design for failure resilience and environmental sustainability. The proposal status is pending.

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### **Progress report (300 word maximum, please focus on results in non-technical terms and commercialization progress):**

Over the past 9 months, the Vermeer-ISU project team has made progress in three aspects of this bearing prognostics project. First, the project team has successfully procured and set up a multi-bearing test rig in the PI's lab for collecting experimental data that are essential to developing new predictive analytics methods for bearing fault detection/diagnostics and failure prognostics. The project team has also evaluated various methods of sensing bearing vibration, acoustics, and temperature, and installed a comprehensive list of data acquisition (DAQ) sensors, modules, and chassis needed to collect the experimental data. The whole lab test system (including the test fixture, sensors, and DAQ) has been up and running since February 2018.

Second, the project team has developed a deep learning approach for multi-bearing fault diagnostics. This approach builds a deep learning model, namely convolutional neural network (CNN), to mine the useful information from large volumes of preprocessed multi-sensor signals. An experimental validation using the multi-bearing test rig shows the proposed approach produces higher diagnostic accuracy than state-of-the-art machine learning approaches. The proposed approach has also been validated via machine testing on a Vermeer baler at the ISU BioCentury Research Farm. Preliminary results suggest the proposed approach, again, outperforms two popular machine learning approaches. Two conference papers have been submitted and one journal paper has been prepared and is ready for submission.

Third, the Vermeer-ISU team has conducting an initial business case assessment. In this assessment effort, the team has worked on three main tasks:

1. Performed 1<sup>st</sup> iteration of customer and market research to define the potential innovation of the prognostic modeling;
2. Translated the innovation into potential financial opportunity; and
3. Assessed how the innovation and \$\$ opportunity fit Vermeer business strategy.



## RIF FUNDING: PROGRESS REPORT

**Report Type:** Final

**Title:** Polyamides with Bio-Enabled Properties

**PIs:** Jean-Philippe Tessonier

**Company Partners (if applicable, company names only):** Sumatra Biorenewables, LLC

**Project Goal:**

Produce 3-hexenedioic acid as a new bio-based monomer for the synthesis of Nylons with enhanced moisture resistance and tunable mechanical properties

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**Publications/presentations based on project:**

Tessonier, J.-P., "Unsaturated Diacids for the Production of Bio-advantaged Nylon", *Corn Utilization and Technology Conference*, St. Louis, MO, June 5, 2018.

**Invention disclosures:**

Tessonier, J.-P.; Abdolmohammadi, S.; Hernandez, N.; Cochran, E. W. "Chemically-resistant Nylon 6,6 for Fluid Handling Applications". ISURF #04780, May 15, 2018.

**External funding applied for (indicate received/denied/pending):**

National Science Foundation Partnerships for Innovation: Accelerating Innovation Research - Technology Translation (NSF PFI:AIR-TT), "Technology for the Production of Polyamides with Bio-Enabled Properties", \$200,000, 7/15/2017-12/31/2018, Received (PIs: Tessonier, ISU; Cochran, ISU; Keeling, ISU).

National Corn Growers Association (NCGA) – Consider Corn Challenge, "Monomers for the Sustainable Production of Commodity and Specialty Polyamides from Corn", \$25,000, Denied (PI: Carraher, Sumatra Biorenewables).

Iowa Biotech Association - Partnering for Growth Showcase, \$5,000, Denied (PI: Carraher, Sumatra Biorenewables).

National Science Foundation Small Business Innovation Research Phase I (NSF SBIR Phase I), "Bio-Advantaged Monomers for the Production of Function-Tailorable Polyamides", \$225,000, 7/1/2018-6/30/2019, Pending-Recommended for funding (PI: Carraher, Sumatra Biorenewables; Sub-Award: Tessonier, ISU). Based on interactions with Dr. Molnar, NSF SBIR program manager, Sumatra Biorenewables will receive the official award notification by June 15, 2018.

Iowa Economic Development Authority SBIR Phase I Matching Grant Program, "Bio-Advantaged Monomers for the Production of Function-Tailorable Polyamides", \$25,000, 7/1/2018-6/30/2019, Pending (PI: Carraher, Sumatra Biorenewables).

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**Progress report (300 word maximum, please focus on results in non-technical terms and commercialization progress):**

The first objective of this project was to identify and develop a relationship with a muconic acid supplier that could also become a valuable partner for Sumatra Biorenewables LLC. We have identified a company and secured 1 liter of unpurified fermentation broth for early testing.

The second objective was to purchase, install, and develop a new flow reactor system for producing 3-hexenedioic acid (3HDA) from muconic acid at a kilogram/month scale. The reactor system was installed in November 2017 and the reaction conditions were optimized using the obtained unpurified fermentation broth. This optimization enabled us to reach a productivity of 1.4 kilogram/month.

Our third and fourth objectives were to develop bio-advantaged Nylon prototypes with enhanced moisture resistance and tunable mechanical properties to initiate interactions with potential customers. We were able to enhance Nylon's moisture resistance by one order of magnitude and we filed a provisional patent on this technology on November 17, 2017. We also demonstrated that this hydrophobicity is accompanied by an enhanced resistance to chemical attacks. Specifically, the synthesized Nylon was found to be resistant to halide solutions, a desired property for fluid handling applications in the automotive industry. We filed a new invention disclosure on this discovery on May 15, 2018. Information gathered through our customer discovery encouraged us to focus our efforts on bio-advantaged Nylon (containing 3HDA), hydrophobic Nylon (containing alkyl-modified 3HDA), and halide-resistant Nylon. Therefore, we postponed the development of Nylon with tunable mechanical properties.

[Type here]

Finally, we worked together with Iowa State University's CyBIZ Lab to build a strong business case and identify early customers. This collaboration also enabled us to submit, together with Sumatra Biorenewables LLC, a competitive NSF SBIR Phase I that was recommended for funding (award letter expected for June 15, 2018).

**RIF FUNDING: PROGRESS REPORT****Report Type:** Final**Title:** Building a Novel Microbial Manufacturing Platform for *de novo* Synthesis of High-value Nutraceuticals**PIs:** Zengyi Shao**Company Partners (if applicable, company names only):** ESTose Biorenewables, LLC**Project Goal:**

This proposed project aims to establish the production of two high-value nutraceuticals, namely naringenin and resveratrol, and determine the minimal viable product (MVP). Naringenin and resveratrol belong to the flavonoid and stilbenoid family of compounds that are associated with antioxidant, memory-boosting and sleep-aid activities. These molecules are currently obtained through extraction of various fruits and vegetables, but the separation process is cumbersome and requires immense quantities of plant tissues. The technology developed by ESTose Biorenewables and Shao group will design high-performance microbial factories to replace the traditional plant cultivation and extraction routes and enable sustainable high-yield production.

**Publications/presentations based on project:**

1. M. Cao, M. Gao, D. Ploessl, and Z. Shao, CRISPR–Mediated Genome Editing and Gene Repression in *Scheffersomyces stipitis*, *Biotechnology Journal*, 2018, DOI: 10.1002/biot.201700598 (<https://onlinelibrary.wiley.com/doi/abs/10.1002/biot.201700598>)

2. M. Gao, M. Cao, Q. Su, and Z. Shao, Building High-performance Yeast Consortia for Producing Naringenin and Resveratrol, 2018 (in preparation)

(1). M. Cao, M. Gao, D. Ploessl, and Z. Shao, CRISPR–Mediated Genome Editing and Gene Repression in *Scheffersomyces stipitis*, poster presentation in AIChE, Minneapolis, MN, 2017

(2). M. Gao, M. Cao, Q. Su, and Z. Shao, Enabling Glucose-Xylose Co-Utilization in Yeast through Expression of Xylose-Specific Transporters, oral presentation in AIChE, Minneapolis, MN, 2017

(3). Z. Shao, M. Cao, M. Gao, L. Zhao, and W. Sun, “Elucidating Core Design Principles to Engineer Nonconventional Yeasts as Novel Microbial Factories”, ACS Annual Conference, New Orleans, LA, March 2018.

**Invention disclosures:**

Z. Shao, M. Cao, M. Suastegui, and M. Gao, Building Yeast Factories for Production of Aromatic Compounds-from Building Blocks to Plant Secondary Metabolites, ISURF#04508 (non-provisional patent application in progress)

**External funding applied for (indicate received/denied/pending):** N/A**Progress report (300 word maximum, please focus on results in non-technical terms and commercialization progress):**

In RIF Phase I, ESTose Biorenewables has completed 3 out of the 4 proposed technical tasks. In particular, multilevel metabolic engineering strategies including removal of transcriptional and translational repression, removal of pathway competition, and increase precursor abundance, and enhance the expression of the key enzymes were implemented; carbon-catabolite repression was relieved by promoter swapping and xylose transporter engineering strategies. The resulting glucose/xylose sugar co-utilization enabled a total production level of shikimate at 4.5 g/L, which represented the highest production level of shikimate pathway-derived molecules produced by yeast platforms. However, a key enzyme in the downstream pathway of shikimate was not expressed at a sufficient level, which constrained the biosynthesis of flavonoids in *S. stipitis*. To address this issue, we are currently developing a yeast consortium composed of *S. stipitis* and *S. cerevisiae*, taking advantage of *S. stipitis* to provide shikimate as a precursor and *S. cerevisiae* to clear off the downstream enzyme expression issues. We recently identified a novel shikimate transporter to facilitate the transport of shikimate from the high producing *S. stipitis* to *S. cerevisiae*.

In addition, 10 interviews were performed with the customers from different market segments such as cosmetics, animal nutrition, pharmaceuticals as well as human health and nutrition. It was learned that the most valuable feature desired by the potential clients, was the possibility of a simpler downstream purification process, which is the biggest pain experienced by anyone working in extracting and purifying flavonoids from plants. The second problem was whether ESTose Biorenewables could perform both lab-scale and medium-scale fermentations and prove the fermentation-based technology combined with the downstream purification is truly advantageous over the plant-based extraction in term of overall cost, which was pointed out by several companies that currently extract flavonoids from plants. Both issues will be targeted once the consortium strategy is proven. We plan to submit a SBIR or PFI proposal in the summer of 2019.

## RIF FUNDING: PROGRESS REPORT

**Report Type:** Final

**Title:** Preparation of ultra-flat metal surfaces by mechanical polishing and/or surface reconstruction

**PIs:** Martin Thuo, Ludovico Cademartiri

**Company Partners (if applicable, company names only):** AEqual LLC

**Project Goal:** Develop a nanolubricant formulation for polishing rough surfaces.

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**Publications/presentations based on project:**

None

**Invention disclosures: none**

**External funding applied for (indicate received/denied/pending):**

None

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**Progress report (300 word maximum, please focus on results in non-technical terms and commercialization progress):**

Aequal is developing a method to polish surfaces or irregular shapes with the goal of increase energy efficiency in bearings. We project that there will be significant advances in realization of the project milestones in the first quarter of 2018 following our success in the last month. So far, the following has been accomplished;

**Project Milestones:**

5. The PIs have acquired and set up the required equipment and initial sample preparations has been accomplished. Due to unforeseen challenges and changes in conflict of interest management, there was a slight delay in obtaining the equipment but it is finally setup and running.
6. Required nanoparticles have been synthesized in significant quantities and switched from an aqueous medium to an oil-based suspension.
7. Steel samples have been polished and are currently being tested. Initial results are derived from current industry standards with the goal of matching current state of the art before embarking on our patented formulation.

The partners at Aequal have not succeeded in reproducing results obtained in the lab during development of the technology. Few samples have been polished and characterization has not been completed by the partners at Aequal. The Cademartiri lab has been investigating alternative formulations based on self-suspended nanoparticles in low surface tension lubricant oils. An invention disclosure will be filed as soon as these formulations are tested in polishing applications. Following the challenges with the industry partner, Co-PI Thuo's lab embarked on development of oxide coated polishing systems based on composition inversion. These new particles will be evaluated for suitability in finishing (fine polishing).

**Business Milestones**

6. A business canvas and pitch deck (presentation) has been prepared with the help of the ISU startup factory. The refinement of the pitch deck and business canvas is on-going with help from Aequal's experts and mentors.
7. Aequal has completed an initial customer discovery process and feedback from these surveys has been integrated into our business model, canvas and pitch deck. With the help from two interns in CyBIZ Lab, an on-going customer discovery process is underway. 5 local Iowa companies are interested in Aequal's patented technology. Additional leads are being explored in states and industries beyond Iowa.
8. Aequal has continued to pitch to various investors and has established contacts with potential investors/funding sources with the hope of attracting new funding for the seed round.

Aequal plans to pursue an SBIR/STTR grant proposals in the near future to strengthen the collaboration and ensure continuous funding for translating this unique technology into commercial use.

## RIF FUNDING: PROGRESS REPORT

**Report Type:** Final

**Title:** Exploring 3D Imaging Technologies for Field Phenotyping

**PIs:** Baskar Ganapathysubramanian  
Pat Schnable

**Company Partners (if applicable, company names only):** DecisionPX, LLC

**Project Goal:**

Resolving challenges towards deploying two very promising technologies in the field – the Kinect based 3D IR scanner, a (terrestrial) laser scanner (TLS).

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**Publications/presentations based on project:** N/A

**Invention disclosures:** N/A

**External funding applied for (indicate received/denied/pending):** N/A

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**Progress report (300 word maximum, please focus on results in non-technical terms and commercialization progress):**

The main activities accomplished in this project are related to a) identification of safe staging protocol of the imaging device in dynamic, field-based environments, b) designing of reliable imaging protocols that ensure consistent data quality, c) data collection, storage, and transfer of data from the field to computing facilities, and d) algorithmic approaches to separate regions of interest from the background and remove noises.

For safe staging of Kinect camera, we deployed (focusing on the stability and easy maneuverability) a four-wheel based cart equipped with portable ac power supply, a data logging PC and camera mounting mechanism. The mechanism has the capability to adjust camera position in both vertical and transverse directions, that allows to focus on the region of interest during imaging. For the TLS (Trimble TX5) we deployed a tubular 10 m tall tower with a specialized mechanism to lift the TLS at different heights along the tower.

To ensure consistent data quality, we deployed (with the cart) a shading canopy to protect against direct sunlight illumination which could potentially lead to poor data quality. For the TLS, we investigated data quality by analyzing the images taken at different times of the day (effect of sunlight intensity and direction) and at different heights (image quality degrades farther away from the TLS).

Using the above imaging protocols, we captured field images of maize plants with both Kinect and TLS. We also captured images (with both devices) of excised maize tassels in lab settings (mounted on a rack).

The large dataset (single TLS image is ~2GB) are stored on a server for easy accessibility for our computing facility. In our facility, we deployed algorithmic pipelines to separate regions of interest (e.g., maize plant or tassel) from the background (soil or weed) and to remove noises produced by the imaging devices. Recently, we developed algorithmic pipeline to skeletonize (to get the basic shape of the object) of 3D images of maize plants and tassels and extract their features.

## RIF FUNDING: PROGRESS REPORT

**Report Type:** Interim

**Title:** Identification of a Non-antibiotic Drug that Prevents BRD at the Feedlot

**PIs:** Steve Carlson

**Company Partners (if applicable, company names only):** AeroGenics

**Project Goal:**

To demonstrate that our anti-BRD drug: is superior to an antihistamine alone; is superior to an anti-inflammatory alone; is non-inferior to the combined use of an antihistamine and an anti-inflammatory; and, can be efficaciously administered via a long-acting/sustained-release injection.

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**Publications/presentations based on project:** None

**Invention disclosures:** The new data was used for the non-provisional patent that was filed in January of 2018. ISURF #04535

**External funding applied for (indicate received/denied/pending):**

None

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**Progress report (300 word maximum, please focus on results in non-technical terms and commercialization progress):**

We have demonstrated that our anti-BRD drug: is superior to an antihistamine alone; is superior to an anti-inflammatory alone; is superior to the combined use of an antihistamine and an anti-inflammatory; and, can be efficaciously administered via long-acting injection. We have also shown that the drug may reduce the expression of a pro-inflammatory lung protein that causes BRD. By doing so, we have bolstered our patent and have satisfied the concerns of our commercial partner-Boehringer Ingelheim. We are now in negotiations with Boehringer Ingelheim and anticipate that a preliminary licensing agreement will be in place by June of 2018.

## RIF FUNDING: PROGRESS REPORT

**Report Type:** Final

**Title:** Rapid Salmonella Detection in Food Processing Facilities

**PIs:** Jonathan Claussen

**Company Partners (if applicable, company names only):** NanoSpy, Inc.; AES Controls

**Project Goal:**

The objective of this proposal was to develop a microfluidic cartridge to interface printed graphene electrodes to provide a disposable, robust platform to deliver up to 15 mL of swab samples collected from high risk areas in the food processing facility (i.e. food contact and work surfaces, tools, utensil handles, floors, drainage sites, etc.).

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**Publications/presentations based on project:**

None yet, but we are gathering the data for a manuscript on a 3D printable microfluidic cartridge

**Invention disclosures:**

None yet, but we will submit an invention disclosure before the submission of the manuscript on a 3D printable microfluidic cartridge.

**External funding applied for (indicate received/denied/pending):**

**Investigators:** Loreen Stromberg, Carmen Gomes, Jonathan Claussen

**Title of Grant:** Handheld Biosensor for the Enrichment Free Detection of Salmonella

**Granting Agency:** NSF SBIR

**Total Award (Amount allocated to Claussen's Lab):** \$225,000 (\$33,000)

**Status:** Denied

**Role:** Subawardee (Nanospy, Inc. was the lead)

**Investigators:** Loreen Stromberg, Carmen Gomes, Jonathan Claussen

**Title of Grant:** Rapid in-field monitoring of Listeria species for food safety using disposable graphene biosensors

**Granting Agency:** USDA SBIR

**Total Award (Amount allocated to Claussen's Lab):** \$100,000 (\$33,000) + \$50,000 IICORP Match

**Status:** Denied

**Dates:** 6/1/2018 - 2/28/2019

**Role:** Subawardee (Nanospy, Inc. was the lead)

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**Progress report (300 word maximum, please focus on results in non-technical terms and commercialization progress):**

Multiple 3D printed designs were taken from the literature and modified according to the specifications of the project objective. Patterns included microchannels of different shapes (square, trapezoidal, spherical) that were incorporated into an overall helix geometry, so that particles of interest (e.g., bacteria) would be focused along a specific plane inside the channel. The separation efficiency of various serpentine patterns was also investigated. CAD files were 3D printed using various 3D printers, or created using an open scaffolding technique in which 3D-printed ABS plastic was cast in polydimethylsiloxane and dissolved to leave an open channel. After fabrication the devices were subjected to testing with fluorescent microparticles ranging from 3-120  $\mu\text{m}$  to evaluate particle separation efficiency. Testing was performed by flowing samples of various particle sizes and concentrations through the microchannels at controlled flow rates. Samples were evaluated using fluorescence microscopy, high speed video microscopy, particle counting, and flow cytometry—to establish how well the channels separated 3  $\mu\text{m}$  microparticles (bacteria-sized), from larger particles in solution. Results indicate that serpentine-shaped channels were effective at focusing larger sized particles (115  $\mu\text{m}$ ) into isolated streams, which is an effective method for isolating non-specific targets to increase detection sensitivity. Helical-shaped channels were also efficient at focusing larger-sized particles, but separating them from solution into a waste stream required additional design modifications. Designs with the greatest separation efficacy and ease of fabrication were serpentine patterns generated with the open scaffold technique. Resulting designs were modified to incorporate graphene electrodes

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into microchannels, and printed using a high-resolution 3D printer. Further testing with live *Salmonella* will assess improvements in the sensitivity of the *Salmonella* biosensor developed by Claussen and Gomes laboratories. Further development will take the finalized design and optimize it for high-throughput production, with an integrated prototype device anticipated by December 2018.



## RIF FUNDING: PROGRESS REPORT

**Report Type:** Final

**Title:** Development of Field Mobile Soil Nitrate Sensor Technology to Facilitate Precision Fertilizer Management

**PIs:** David Laird

**Company Partners (if applicable, company names only):** N-Sense, LLC

**Project Goal:** Our long-term goal is to develop and commercialize a soil nitrate sensor system that can be attached to a fertilizer applicator and used to measure soil N status in-real-time and thereby facilitate precision N fertilizer applications. Our specific goals for the RIF project are to: 1) build and test a basic prototype system for collecting on-the-go mid infrared spectra of soils, and 2) to build our calibration and validation data base by collecting diverse soil samples from across the state of Iowa and analyzing those samples both in the laboratory and using our sensor system.

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**Publications/presentations based on project:**

We have given numerous elevator pitches to interested groups and potential investors, including:

09-06-17 SBIR Showcase, Iowa City Iowa (NSF, USDA)

11-09-17 Ag Tech Investor Conference, Des Moines (DuPont Pioneer, Ag Ventures Alliance, Iowa Corn Promotion Board)

11-17-17 Breakthrough Energy Ventures (Peter Turner)

We have one peer reviewed publication which was submitted to the journal Precision Agriculture before the start of the RIF. We have recently received reviews back from the journal and are working on revisions of this manuscript. The paper is entitled: "Development of Field Mobile Soil Nitrate Sensor Technology to Facilitate Precision Fertilizer Management". We anticipate that the manuscript will be formally published in 2018.

**Invention disclosures:**

None during this period

**External funding applied for (indicate received/denied/pending):**

1) NSF SBIR Phase 1 proposal entitled: "Field Mobile Soil Nitrate Sensor for Precision Fertilizer Management". Status: denied.

2) USDA NIFA SBIR Phase 1 proposal entitled: "Algorithm development for data pre-processing, analysis and calibration of FTIR spectra for soil nitrate prediction". Status: Pending.

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**Progress report (300 word maximum, please focus on results in non-technical terms and commercialization progress):**

In partnership with our private industry partner, N-Sense, LLC, we built and ran initial field tests of a prototype of our field mobile soil nitrate sensor system (see photo). Approximately 16% of the spectra obtained with this "zero prototype" were usable. From this test we learned that it is possible to obtain usable FTIR spectra of soil under field mobile conditions; however, we also learned that our design concept will need to be modified to increase the percentage of usable spectra. We are considering further refinements in the sensor design.

N-Sense collected 294 soil samples from 11 agricultural fields across the state of Iowa. GPS coordinates were collected along with each soil sample. The soil samples were brought back to our ISU laboratory and are being stored field moist in a cold room until they can be analyzed. In the laboratory, we are analyzing these 294 new soil samples with our FTIR spectrometer to obtain spectra and the same day using an extraction/colorimetric procedure for nitrate (a standard wet chemistry analytical procedure for soil nitrate). When the laboratory analyses are complete, we will use the data to build and test chemometric software that uses the spectra to predict soil nitrate concentrations, which we will compare with the laboratory measured soil nitrate concentrations.

Commercialization of the technology is being pursued by N-Sense, LLC. N-Sense is conducting customer surveys, building a business model, and working with potential investors to secure the funding resources needed for the company to design, build, test, and start producing commercial products.

**RIF FUNDING: PROGRESS REPORT****Report Type:** Final**Title:** Evaluation of Spontaneous Genome Doubling Ability in Haploids of Diverse Genetic Background**PIs:** Ursula Frei  
Thomas Lubberstedt**Company Partners (if applicable, company names only):** Wyffels Seed Inc, Forage Genetics International, Syngenta, Advanta Seeds (Argentina)**Project Goal:** The goal of this project is to evaluate the trait of Spontaneous genome Doubling Ability in Haploids (SHGD) in the genetic background of actual breeding lines provided from different corn breeding companies.**Publications/presentations based on project:** -**Invention disclosures:** ISURF 04636**External funding applied for (indicate received/denied/pending):****Received**

<u>T Lubberstedt (PI)</u> <u>K Delate</u> <u>W Tracy</u> <u>P Scott</u>	USDA-OREI	10/2017-9/2021	\$1 Mio	Novel strategies for developing organic field and sweet corn varieties
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**Denied**

<u>T Lubberstedt (PI)</u>	USDA Foundation	03/2018-02/2022	\$500,000	Genetic analysis and application of spontaneous haploid genome doubling in maize
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**Pending**

<u>M Settles (PI)</u> <u>W Tracy</u> <u>C Hannah</u> <u>T Lubberstedt</u> <u>A Block</u> <u>M Resende</u>	USDA-SCRI	9/2018-8/2022	\$ 8 Mio	Sweet CAP: Integrated technologies to improve sweet corn production and marketability
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**Progress report (300 word maximum, please focus on results in non-technical terms and commercialization progress):**

In summer 2017, crosses between different donor lines of the SHGD trait and the actual breeding lines submitted by the collaborating companies were performed. Based on recommendation of the participating breeding companies, 6 public available control lines representing the Stiff Stalk and Non-Stiff Stalk heterotic group were added to the experiment. We were able to combine each breeder line with three different SHGD donor lines. The resulting F1 seed was grown at a winter nursery in Chile for haploid induction. Induction crosses with the breeder and control lines have already been performed during the summer 2017 season. Selection of haploid was done during the winter. One of the breeder lines could not be selected based on the color marker R1-nj. Haploid seed returned from the winter nursery in late April. For most of the combinations sufficient haploid seed was recovered for the planned experiment.

The SHGD evaluation block was planted at the Ag Engineering and Agronomy Research Farm during May. Haploids derived from each breeder line, the controls and the respective combinations with 3 different SHGD donor lines were directly seeded in 4 rows a 25 seed each. The remaining haploid seed were germinated in the greenhouse and at the 2-3 leaf stage treated with colchicine solution for chromosome doubling. The seedlings were transplanted to the field adjacent to the directly seeded plots. For the breeder line that could not be selected based on the color marker R1-nj, a larger number of induced seed was germinated for root color selection. Seedlings with white roots were either directly transplanted or treated for chromosome doubling before transplanting.

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Restoration of male fertility will be scored with and without colchicine treatment during the summer, and the participating breeding companies will have the opportunity to evaluate the performance of their germplasm in comparison to other breeder's material and the controls.