WHIN

WABASH HEARTLAND
INNOVATION NETWORK

Report to Lilly Endowment

September 2020

Submitted by: Johnny Park, CEO, WHIN

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Message from the Chairman:

It is difficult for me to realize that we are completing the third year of our five-year grant period from the Endowment. As I look back on the past several years, I realize all the progress we have made and I better understand the distance we have yet to travel in order to accomplish our vision. Our vision statement, we call it our true north statement, is: *The Wabash Heartland Innovation Network exists to create an ecosystem that enables globally-competitive businesses to plant and grow in the Wabash Heartland.* We are all about developing an ecosystem that provides the attributes our agricultural and manufacturing sectors need to advance their global competitiveness. We also want to encourage the "planting" of new opportunities and investments in our region—to attract those like-minded investors that want to be a part of this globally competitive environment. Our belief has been, and continues to be, that accelerating our region's globally competitive position will result in an increase in our regional economic prosperity, which will positively impact the lives of each of the residents in our ten-county region. It is also our belief that our efforts will not only impact our region, but our state, our nation, and the world.

The linchpin of our efforts to achieve these aspirations is the adoption and advancement of the Internet of Things (IoT): creating, shaping, and advancing digital agriculture and championing, developing, and deploying technology to accelerate the adoption of Next Generation manufacturing or Industry 4.0. The generation of data created by IoT sensors and devices by itself isn't very exciting or helpful but the generation of data to develop actionable solutions to real world problems is exciting, necessary, and compelling. The creation of our ten-county living laboratory provides us the opportunity to create the ecosystem that brings the required resources together—talent, research, demonstration, education, engagement, financial investment, leadership, and a lot of hard work—to build this place where globally-competitive businesses will plant and grow.

No one really "owns" this effort. This is a coalition of the willing, the collaboration of many stakeholders. This requires leadership and vision, but it also requires Purdue, Ivy Tech, and our K-12 educational system. This effort requires the engagement and investment of our business partners within the region but also our tech partners that bring their resources to us from all over the world. For us to be successful, we need the support of our local, state, and national leadership and many others that will invest and join hands to intelligently build the future of this place we live and call home—but also the places of others both near and far. The impact of the Wabash Heartland Innovation Network is being seen and felt in places that were unimaginable just a short time ago—**and we are just beginning!**

I hope you enjoy reading our report. We are excited to share this update with you. It is truly an honor and a pleasure to work with the wonderful team at Lilly Endowment who have been, and continue to be, such a positive force for good in our state and in the Wabash Heartland Region.

Gary D. Henriott, Chairman

WHIN Overview: **Connecting in a Time of Social Distancing**

It has been an interesting six months to say the least. No sooner had we completed the March 2020 report then COVID-19 hit.

With the pandemic, WHIN partners Purdue and Ivy Tech faced enormous challenges, not only with WHIN activities but with having to prepare their campuses for extraordinary safety over an indeterminate length of time.

The impact of the pandemic on WHIN-sponsored research and education at Purdue and Ivy Tech is included in this report.

The WHIN team had to adjust as well. Staff has worked from home for the past several months, though recently some have begun coming to the office for a couple of days a week.

But we are on Google Meet not only for meetings but just to feel connected as a team. We all miss that sense of connectedness. We tried daily group Pomodoro-style sessions, an hour where each person shared what their 25-minute task would be and then summarized their progress between segments. That lasted less than two weeks. Another attempt, simply working together in a Google chat room with open cameras and mics didn't make it past about day three, with the noise of keyboards, breathing, and coffee drinking proving to be major and creepy distractions.

In the end, we settled on spontaneous "coffee breaks"—getting together in a Google chat room for 15-30 minutes when summoned by Audette to talk about anything but work. Those who are able to make it enjoy tours of backyards, favorite film clips, meeting kids and pets, and the spontaneous hilarity that is a staple of our very smart and creative crew.

Of course, the main impact of the pandemic on WHIN has been on programming.

Both our Ag and Manufacturing Alliances slowed down for several months as farmers focused inward in the face of huge market upheavals and manufacturers juggled the twin challenges of supply chain disruptions and maintaining an adequate healthy workforce. Most manufacturing plants in the region are still not open to non-employees, making it difficult to conduct Alliance business.

But the pandemic cloud has also had a silver lining. The hiatus was a great time for WHIN to take some time off the road to work on its Customer Relationship Management (CRM).

The early stages of both the Ag and Manufacturing Alliances were characterized by a modest hot market of prospective members who were already interested in adopting IoT. But we have needed a pipeline for some time: a differentiated outreach program that lets us meet farmers and manufacturers where they are and step them through a process of learning about WHIN and IoT before committing to joining an Alliance.

And the pandemic has caused WHIN to greatly accelerate initiatives to address the 'I' in IoT. We weren't the only business to move online, and in our rural region the digital divide is being keenly felt.

We know, for example, that two-thirds of households and one-third of businesses in the region do not have 100 Mbps down/10 Mbps up broadband service, a level that can accommodate the high-bandwidth applications like video-streaming that are needed for remote work and learning. Ten percent of homes don't even have the very minimal 25/3 Mbps service.

Team retreat, pandemic style.

WHIN Overview: **Connecting in a Time of Social Distancing** *(Cont'd)*

RTO Wireless AeroSite™

COVID-19 has dramatically increased the demand as employees work and students take classes from home. This impacts not only quality of life—important as that is to WHIN—but the ability of businesses to operate safely.

And lack of connectivity was already a drag on Alliance activities. Sensors need to be connected to have value and, in rural areas, they are typically deployed much more densely than are human Internet users. Cellular service can be unreliable in rural areas, and it is very expensive for IoT applications.

Of course, WHIN is not an ISP. But its unique Alliance model is just as able to accelerate the adoption of innovative connectivity solutions as it is to accelerate the other side of IoT, sensors. WHIN vets innovative technology that is likely to have immediate impact, puts it to real use, and gathers data from that use for research and education.

So, instead of conventional, expensive, and slow-to-implement buried fiber, we invested in efficient, rapidly-deployable, vertical fiber: an aerostat. Specifically, an RTO Wireless AeroSite™. We also engaged two of what should be the first of many tech partners to make it operational for the region.

Also, we are equipping our aerostat with newly-allocated Citizens Broadband Radio Service (CBRS) spectrum for broadband as well as an emerging IoT-friendly protocol, LoRaWAN.

When deployed, which we are aiming to do by the end of 2020, our aerostat is expected to reach the entire region with LoRaWAN and at least a 20-mile, multi-county radius with high quality CBRS. An aerostat is not only very efficient in reaching long distances, its 1500-foot altitude gives it access to the places where service is poorest, behind tree lines and in difficult terrain.

As well, we are deploying LoRaWAN and CBRS gateways on the ground to complete our research network. That will allow us to generate use cases to help the region, state, and country to develop a rapidly-implementable, affordable, and accessible model for rural broadband.

We will be the first in the nation to accomplish a long-term deployment of aerostat technology for rural broadband. Many eyes are watching. WHIN's aerostat project was recently highlighted in Microsoft's newsletter for its own rural broadband initiative AirBand. We are hearing from others around the state and country.

Perhaps most importantly, the focus on broadband is helping WHIN integrate all of its parts in way it has not been able to do until now. This form of connectivity is key to our future.

Indeed, one of the most important uses for our network will be to support e-learning. The WHIN Board has allocated $5 million from the RCF and we have been awarded another $1 million from North Central Health Services (NCHS) for a three-year e-learning program that will also be groundbreaking.

So how has the pandemic impacted WHIN?

We are more connected and connecting—stronger and better positioned to make the impact on the region that was envisioned for WHIN than we were pre-pandemic.

And we are doing this with joy. We have seen a new spark of engagement, made lots of new friends, and are truly excited about the future.

Zach • Ted • Pat • Josh • Johnny • Jess • Jason • Jack • Greg • Chad • Alivia • Audette

Connecting With the Past: **Notching Another First in Aviation**

In a region that has seen many aviation and aerospace firsts

As is always the case when talking with Purdue Dean Emerita of Students, Betty Nelson, one thing leads to another. Fifteen months ago, when the idea of adding an aerostat to WHIN's suite of IoT technologies was just a gleam in Johnny's and Jack's eyes, Pat introduced Jack to Betty at a community event where WHIN had been on the agenda. The conversation turned to the impact of technology on education. Betty, whose professional passion was accessible education for all, had seen an article about school buses being outfitted with WiFi and driven around rural areas to give students Internet access at home. Jack mentioned the aerostat. Betty thought it would do just fine and we should paint it to look like a school bus. In fact, she said, it wouldn't even be truly novel! Providing K-12 instruction from the sky had been done before, right here at Purdue, in the early 1960s: the Midwest Program on Airborne Television Instruction (MPATI). The aerostat idea glowed a little brighter from that point on and using it for e-learning simply made sense.

Students in the 1960s benefiting from MPATI.

(PADA0000106. Purdue University Karnes Archives and Special Collections, Purdue University Libraries)

MPATI on the ground.

(PADA0000103. Purdue University Karnes Archives and Special Collections, Purdue University Libraries)

> *Courage is the price that life exacts for granting peace. The soul that knows it not, knows no release from little things.*
>
> – Amelia Earhart

Dean Emerita of Students, Betty Nelson, and Marianne Rose, retired CEO of the Community Foundation of Greater Lafayette, discuss another local first in aviation—Amelia Earhart—who was a consultant in women's careers and aeronautics at Purdue. Earhart's final flight began at the Purdue Airport.

WHIN is set to continue a long and proud tradition

Purdue is famously known as the cradle of not only quarterbacks, but also of astronauts. Its airport was the first university-owned airport in the country. The university is ranked first in aviation degrees.

The regional economy reflects Purdue's strength in aviation and aerospace. GE Aviation's LEAP engine plant in Lafayette and SAAB Global Defense and Security's facility in Purdue's Discovery Park District, manufacturer of part of the advanced pilot trainer aircraft for the United States Air Force, join Butler Aerospace & Defense in the Purdue Research Park as the hub of the area's aerospace cluster.

Compared with the first man to walk on the moon and the advanced aerospace technology being developed and built in the WHIN region, MPATI would seem to be a mere aviation footnote, and a modest, hopelessly outdated footnote at that.

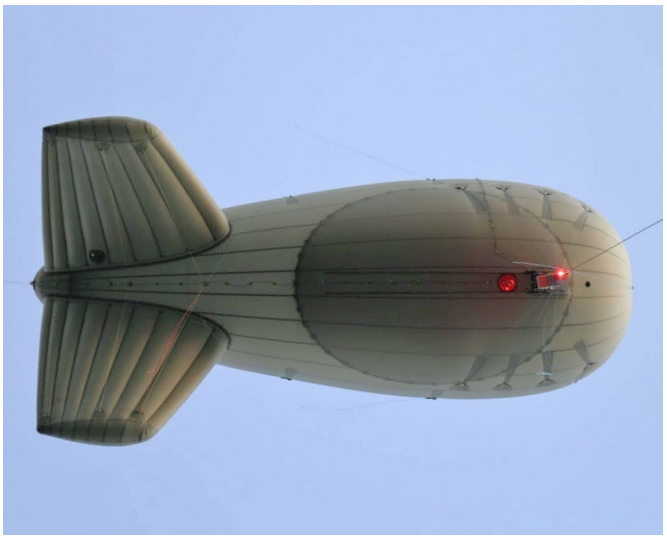
But in 1960, when MPATI, dubbed "Project Stratovision," debuted under Purdue's auspices, it was a first, operationalizing an intersection among education, broadcast technology, and aviation that we might recognize today as plugging a gap not unlike our own digital divide.

With its pre-recorded lessons, MPATI was an affordable way to give more students consistent, high-quality instruction from the most skilled teachers. It foreshadowed the distance education of today.

But as a medium, the airplane-based broadcasting of those lessons was also a model of educational accessibility enabled by technology. As the planes flew their figure-eights over six Midwest states, their signals could be picked up anywhere in the planes' line-of-sight for display on analog televisions in schools.

We might say that where MPATI bridged an analog divide, the aerostat can bridge the digital divide, giving students interactive access not only to their own classrooms from anywhere on the Internet, but to all of the resources that cyberspace has to offer.

Bonus: the aerostat uses no carbon-based fuel. It requires a simple, 2-acre compound, not an airport. It is quiet and unmanned.



Rural Technology Operators (RTO) Wireless AeroSite™ in flight.

MPATI plane in flight.

(PADA0000109. Purdue University Karnes Archives and Special Collections, Purdue University Libraries)

Connecting With Community: **WHIN Prepares to Take Flight**

Finding and feathering

WHIN's aerostat deployment will be the first long-term deployment of an aerostat for rural broadband in the country. AT&T uses RTO Wireless AeroSites™ for short-term flights to support its FirstNet disaster recovery program. But it's one thing to park an aerostat for a couple of weeks in an emergency like a hurricane and quite another to find it a home that serves its needs for months and years.

That kind of home is under the authority of Area Plan Commissions and Zoning Boards. But there are no aerostat ordinances! So, siting and permitting the very first long-term aerostat has been interesting and challenging.

If that weren't enough, the ideal location for the aerostat in WHIN's long-term plan is skewed north in the region, in White County. But White County notably houses a very large array of wind turbines! It is also overspread from the north and east by military airspace that serves Grissom Air Reserve Base.

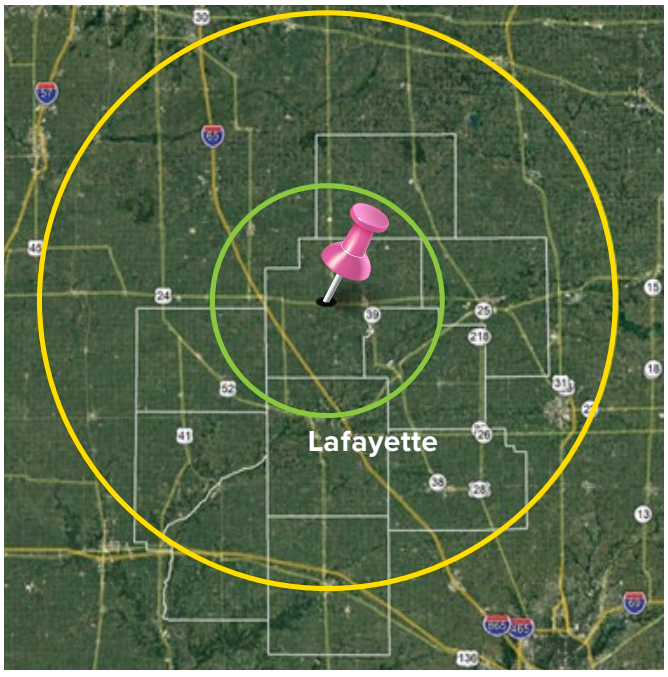
Making things even more challenging is WHIN's need for speed. WHIN's deployment is happening in an emergency: a national emergency has been declared due to COVID-19, and our aerostat is an emergency response even though it will continue past the end of the pandemic.

As it turns out, the closest analogy to a telecommunications aerostat is a cell tower. But in the best of circumstances, a new wireless facility—an ordinary cell tower—typically takes several months to permit. And that is after a site is found with a willing landowner.

We started looking for a site in July and the first month or more was spent trying on various locations for size. This meant clarifying site requirements and mapping those to White County's wireless facility zoning requirements and very limited airspace. It was quite the learning curve for everyone involved.

Thankfully, White County has helped in every way it possibly can, always looking for ways to say yes. As well, our project has temporary options for permitting during COVID-19. It was the team effort of all time, but we are scheduled to be heard at the November Area Plan Commission meeting. Deployment is planned by the end of the year. In addition to a county that welcomes an aerostat, there must be a landowner who is willing to make precious land available.

In having this need met, WHIN has been, quite simply, blessed.



Yellow circle: 50 mile radius for LoRaWAN IoT connectivity
Green circle: 20 mile radius for CBRS broadband connectivity

RTO Wireless AeroSite™ Siting Guidance

Site must include:

1. 1-3 flat acres of ground
2. Secure perimeter fence
3. Circular clearance zone for AeroSite™ as it spins on mooring station
4. 45° angle upwards from the perimeter of the circular clearance zone
5. 220 AC power—peak use of 30kW
6. Electrical ground ring—tied into lug bolts on mooring station
7. Ground anchors (in some cases)
8. Minimum of 250 feet of fiber cable between mooring and edge facilities

the aerostat's nest

By late August, with hope for fall deployment fading, the search area for a workable site in White County had narrowed to just a few square miles west of Reynolds. The best option was a field owned by Ron and Nancy Seymour. We didn't know the Seymours, who had retired to live in Kentucky, and they knew nothing about WHIN. Talk about cold calls!

Ron and Nancy Seymour

But that call began to establish connections that seemed almost to follow a Hollywood script. For example, Ron is not only a Purdue graduate, he is a Purdue aviation graduate. After receiving Associate and BS degrees in 1966, Ron was commissioned a 2nd Lieutenant in the U.S. Air Force. In Vietnam, he flew C-7A's (Caribou) in support of Special Forces and was awarded the Distinguished Flying Cross and five Air Medals. Over his Air Force career, Ron received the Meritorious Service Medal and the Air Force Commendation Medal, flying C-141, A-37, and A-10 aircraft. After retiring from the Air Force as a Lt. Colonel, Ron flew B-727, B-757, and B-767 aircraft for UPS before retiring from flight in 2009.

And don't let the move to Kentucky fool you! Both Ron and Nancy have deep roots in White County, where they also have a home on Lake Freeman, family, and lots of acres in production. Dirk Fleck does the heavy lifting farming the land, but Nancy, who is the farmer in the family in addition to being a retired cosmetologist, works very closely with him to manage the land she cherishes.

The site is part of a field that was in Ron's family. Making the decision to give up productive land for an aerostat is very difficult. The Seymours' willingness to host is courageous on many levels and marks their forward-looking spirit. WHIN will roll back the top soil so the site can be restored when the aerostat is decommissioned.

The Seymours are a blended family, with five children and eight grandchildren between them.

In the end, getting everyone on the same page to finalize site selection required some good old-fashioned Hoosier hospitality: a more-or-less socially-distanced, doughnut-fueled tailgate gathering in a harvested bean field across from the proposed site.

In attendance: Site owners Ron and Nancy Seymour, site farmer Dirk Fleck, White County Commissioners John Heimlich and Steve Burton, Reynolds Town Councilman Sid Holderly, White County Area Plan Director Joe Rogers, White County Economic Development President Randy Mitchell, First Group Engineering VP Mark Norville, Carroll-White REMC Line Superintendent Travis Curtis, RTO Wireless CEO Steve Hubbard (traveling in from Massachusetts), COO Dave Duplissis (coming in from Maine), and CTO Rob Reagan (from Silicon Valley). Plus Johnny, Jack, Pat, and Audette. Also in attendance was neighbor and super-friend of the project, 89-years-young Glenn Ruemler and his son. Glenn is thinking of opening a lemonade stand in his much higher traffic neighborhood!

Connecting with Those in Need: **Purdue-WHIN COVID Response**

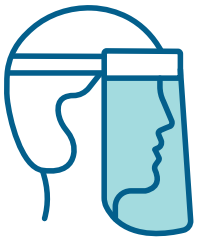
As the COVID-19 pandemic in Indiana initially accelerated, it quickly became clear Indiana's healthcare providers did not have much-needed personal protective equipment (PPE) to safely serve those in need.

That is when Purdue stepped up to help—with Purdue-WHIN faculty and resources playing a vital role.

Known as the Purdue's Boiler 'Maker' team, this ambitious campus-wide initiative was led by Prof. Nate Hartman, co-PI for the WHIN proposal and co-director of Indiana Manufacturing Competitiveness Center (IN-MaC). Boiler 'Maker' encompassed more than 40 faculty, students, and staff from at least six colleges and six centers across campus. "We effectively launched a PPE start-up in less than three weeks," said Hartman.

Every piece of PPE developed went through the IN-MaC's Intelligent Manufacturing Testbed (IMT), funded by WHIN, for final packaging, tracking, and delivery. A number of PPE items were designed and produced there as well. The IMT was the perfect resource for responding to this unique crisis, said Hartman.

> *A key element of the Boiler 'Maker' team's success was using the many streamlining processes Purdue-WHIN teaches regional manufacturers every day. This has been a powerful experience, seeing everyone step up and do what they can to make a difference. This was also a valuable first-hand perspective, facing production and delivery demands. I really believe we will serve manufacturers even better now.*
>
> – Prof. Nate Hartman

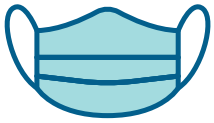


Birck Nanomanufacturing Center and its roll-to-roll manufacturing facility was also vital. 3M donated 17,000-square-yards of polyester substrate to Purdue, and the Birck team immediately began production of face shields. Roll-to-roll laser cutter was running nine hours a day, with volunteers each working three-hour shifts.

"The investment by the SMART industry consortium and WHIN has created a foundry for flexible and Internet of Things (IoT) devices," said Ali Shakouri, Director of the Birck Nanotechnology Center and the faculty lead for the Purdue-WHIN team. "We hope this will be a nucleus to attract high-tech companies to the region."

Between March and July, the entire Boiler 'Maker' team developed and delivered more than 48,000 pieces of PPE, serving both front-line medical personnel and the campus community with:

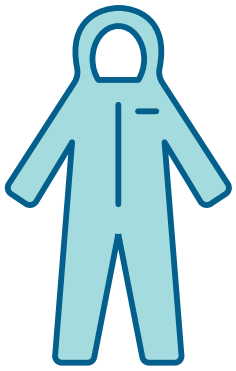
- Nearly 35,000 pieces of PPE donated to medical personnel throughout Indiana, including: splash glasses, surgical caps, foot covers, interchangeable adapters for self-contained respirators, full-body Hazmat-style suits, and two types of face shields.



- Over 15,000 face shields to date for Protect Purdue, a campus-wide program dedicated to improving student safety from COVID.

Due to the nature of the crisis, Boiler MAKER team often had to work quickly. In one case, hospital personnel, fire fighters, and police had full-body, Hazmat-style suits that they were ready and willing to share among their region's medical personnel. But, they learned, the various suit models had different oxygen tank nozzles and hood fittings than the ones used by the medical personnel. As a result, no organization was able to effectively share their suits with another.

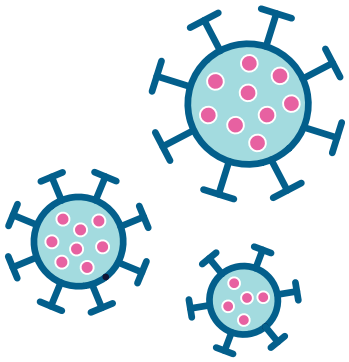
Connecting with Those in Need: **Purdue-WHIN COVID Response** *(Cont'd)*



Within 72 hours, the Boiler 'Maker' team at IN-MaC designed a new adapter that could connect each organization's suit with all of the other organizations' oxygen tanks and hoods. Entirely new nozzles were delivered within seven days— resulting in the donation of much-needed protective suits.

The Boiler 'Maker' team, meant as a crisis intervention, is now winding down its efforts. But INMaC is still working on key COVID-19 challenges. One such example is Prof. Hartman and his team have developed final prototypes of an N95-compliant mask with an easy-to-replace filter; the current commercial masks are designed to be one-time use.

"This is a challenging time, but this served as a good reminder for manufacturers to keep an open mind and look at the assets you have today," said Ted Fiock, managing director of Purdue-WHIN. "It is important to remain agile and move in new directions. This team is really demonstrating new ways to do that."



The Birck team for Purdue-WHIN produces PPE with supplies donated by 3M. Pictured from left: Guy Telesnicki, Nick Glassmaker, Prof. Mukkerem Cakmak. *(Purdue University photo/Jared Pike)*

Connecting the Data: **WHIN's Ecosystem Goes Full Circle**

WHIN launches it's data portal

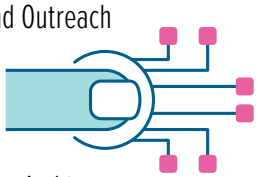
The concept behind WHIN's Alliance model is simple: accelerate the adoption of a common set of IoT technologies in a living lab and collect data from the use of the technology for researchers and educators. But making that data available is a technological feat in and of itself.

WHIN collects a huge amount of very diverse data. Its dense array of weather stations report temperature, humidity, solar radiation, precipitation, wind speed and direction, and soil moisture and temperature at four depths every 15 minutes—and has been doing so for over a year. Starting in the 2020 growing season, WHIN began receiving high resolution images from hundreds of thousands of acres. Also in the data lake? Data from the operation of farm equipment of 30+ Ag Alliance members.

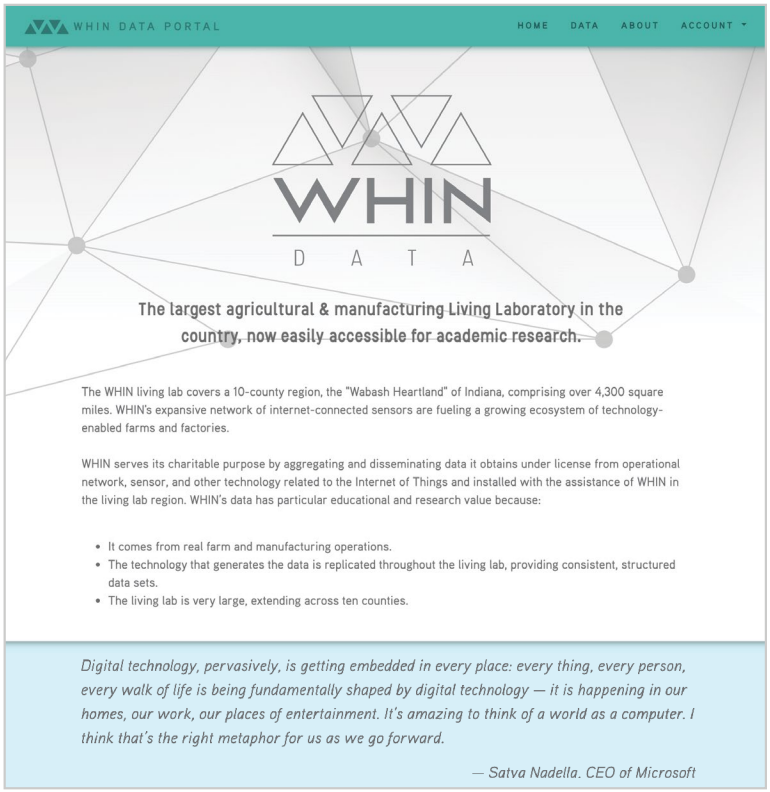
To help researchers and educators connect with all that data, WHIN's Data Portal was launched over the summer. The portal can be used to request sample sets and to contact WHIN to arrange for specific data sets.

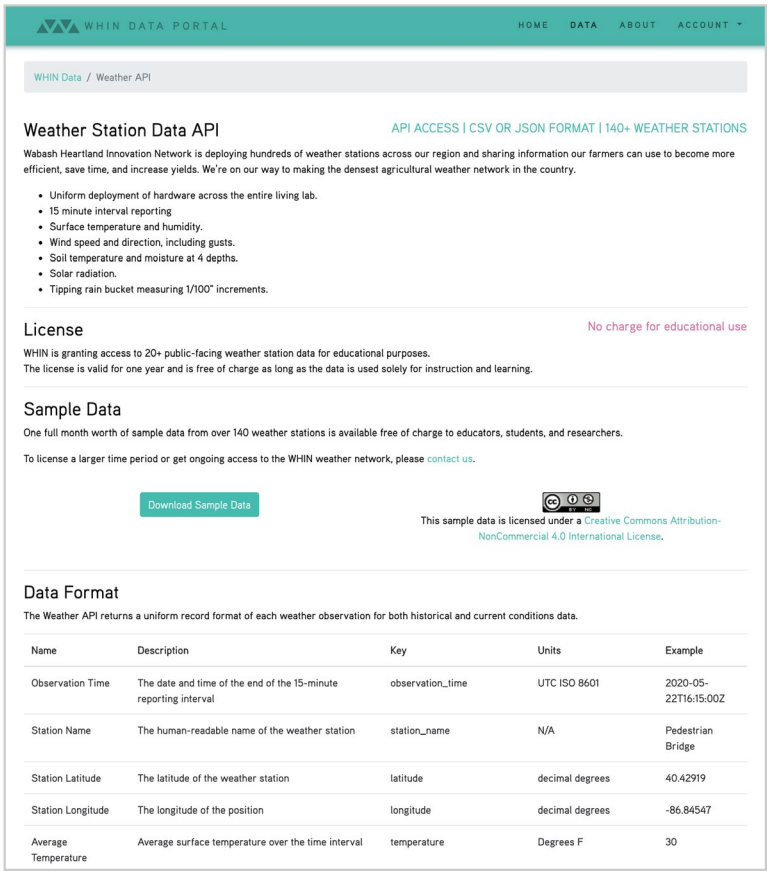
WHIN held its first Q&A meeting for Purdue researchers in August. Interested departments included:

- Agricultural & Biological Engineering
- Department of Food Science
- Indiana State Climate Office
- Agronomy Education and Outreach
- Computer Science
- Civil Engineering
- Agronomy
- Horticulture & Landscape Architecture
- Ag Economics
- Department of Earth, Atmospheric, and Planetary Sciences
- ITAP Research Computing
- Purdue Center for Regional Development



WHIN will continue to work with researchers to understand and meet their needs.





Connecting the Data: **WHIN's Ecosystem Goes Full Circle** *(Cont'd)*

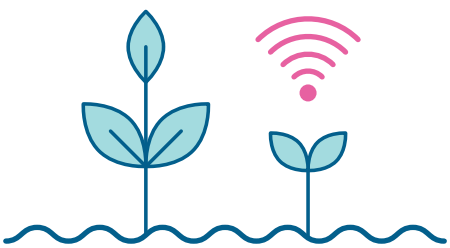
and finds an educational partner in Purdue's Data Mine

A very important stakeholder in WHIN's data lake is educators, and Purdue has made data literacy a campus-wide priority. The idea is to prepare students in every discipline to have a working knowledge of data analytics that will give them an edge in the job market. The initiative recognizes that, thanks to IoT, the world is getting smarter. There is, therefore, a growing need for workers who have not only traditional job skills, but who also can extract new knowledge from the enormous amount of data IoT generates.

But for 600 undergraduate students in Purdue's Data Mine learning community, becoming data fluent is a 24/7 immersion experience. Data Mine students live together in Hillenbrand Hall and work together on collaborative, interdisciplinary projects developed for them by corporate and campus partners who give them access to real world data and guide them through solving specific problems with the data.

In the Fall 2020, semester, WHIN joined Bayer Crop Science, Beck's, CAT Digital, Cummins, Delta Faucet, Elanco, Ford, Jobvite, John Deere, Kraft-Heinz, Lawrence-Livermore National Laboratories, Merck, Microsoft Minecraft, MITRE, OneAmerica, Rolls-Royce, Sandia National Laboratories, TMap, UPS, and Viasat as a corporate partner. WHIN's data is well-suited for classroom projects.

The partnership developed after Data Mine Director and professor of Statistics, Dr. Mark Ward, invited Johnny and Jack to present to students last spring. Jack asked how many of the 70 students present knew that agriculture includes data and cutting-edge technology. Two raised their hands. By the end of the presentation, all 70 let Jack know they got it: a career in agriculture had become an exciting new option for these data-minded students.



Data Mine students in a seminar class.

Locating a WHIN weather station at Hillenbrand Hall.

Connecting People: **Ivy Tech Leadership**

From WHINterns

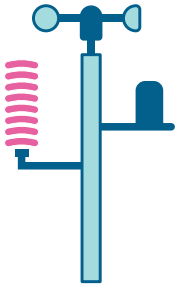
Chad Martin

Even as Ivy Tech was locked down over the summer due to the pandemic, Ivy Tech Project Manager, Chad Martin, led four Ivy Tech and Purdue students in internships, aka WHINternships.

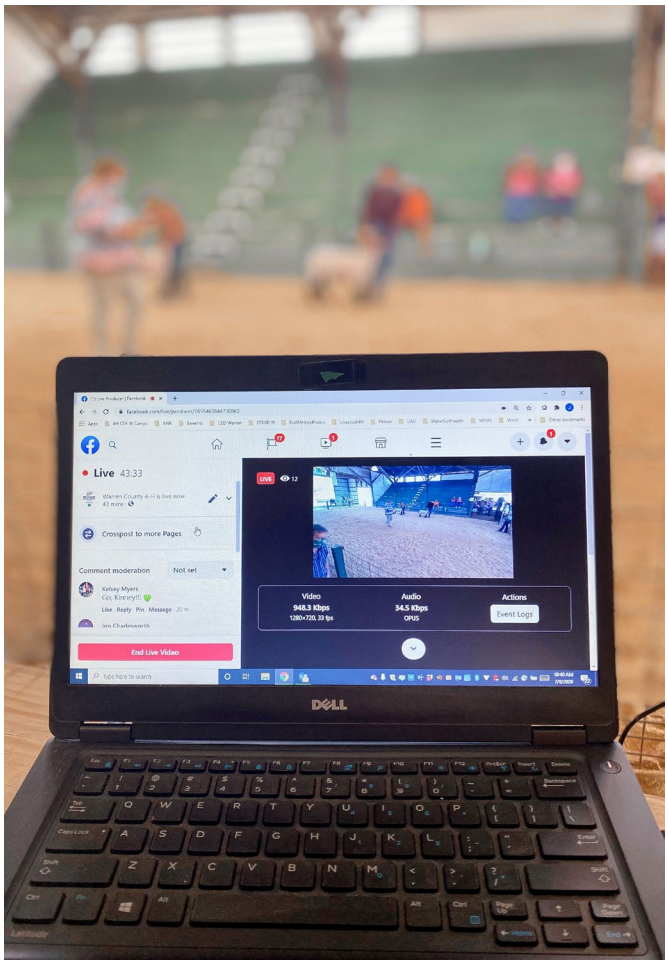
As they honed their professional skills, Brian Butzen, IT student at Ivy Tech, Perry Drum, Cyber-Security major at Purdue, Jenna Hall, Marketing major at Purdue, and Nicholas Wallner, Engineering major at Purdue made significant contributions to WHIN, including its COVID response.

COVID caused major disruptions to county 4-H fairs regionwide. The team of interns installed a temporary MiFi unit at both the Warren and Benton county fairs to enable live streaming of fair activities so more community members could participate safely. The interns set up the hardware, tested bandwidth, and provided instructions for use for fair staff and volunteers.

Another assist the WHINterns gave to WHIN's COVID response was to patiently test MiFi devices from several carriers. Following a grid that marked out 5-mile squares over the ten counties, the team collected actual performance data. That data is helping WHIN design its upcoming elearning project.



The interns also helped install weather stations on farms of the WHIN Ag Alliance. They were able to observe the process of the siting and deployment of the WHIN Aerostat broadband connectivity project.



Streaming the Warren County 4-H Fair.

Jenna was involved in WHIN social media and marketing efforts, including locating and communicating with social media influencers in the region.

The WHINterns worked with Ivy Tech faculty and staff on a campus network to collect data from Ivy Tech's manufacturing testbed. They helped to design table-top trainer units, and created a repository of digital agriculture educational resources for use at Purdue as well as Ivy Tech.

Connecting People: **Ivy Tech Leadership** *(Cont'd)*

to WHIN's newest Board Member, Andrea Schwartz

Andrea with husband Tanner and children Layla and Logan on their farm in Carroll County.

WHIN's board recently added its first new member since inception. Andrea Schwartz, Dean of the School of Advanced Manufacturing, Engineering and Applied Science, and Associate Professor of Agriculture at Ivy Tech Lafayette was selected over the summer to take one of the positions appointed by the board of The Community Foundation of Greater Lafayette.

Andrea has a BS in Agriculture Education and MS in Agriculture and Extension Education from Purdue and her roots in both education and agriculture run deep.

Though she always knew she wanted to teach, it took absence from a farm for Andrea to realize she loved and missed the community of agriculture. That she became a community college educator was perhaps also meant to be. Her dad, who received his formal education in ruminant nutrition from Michigan State, taught for ten years at a vocational school in Minnesota, before beginning a long career in the feed industry.

Andrea brings a passion for students to her work. In college, she worked for the state 4-H office. At Ivy Tech, her great joy is to teach her students to "grow through life," helping them discover their own talents and possibilities. When she took students around the country for livestock judging competitions, she knew that, for many, it was the first time they had traveled, sometimes beyond their home county. To Andrea, the opportunity to expand horizons is often the greatest gift she can give her students.

And that is the spirit she brings to the WHIN board as well. Andrea values WHIN as a way to disrupt the present and look into the future of ag.

Andrea's accomplishments were recently recognized by Purdue as she was named a Distinguished Alumna.

Andrea, age 3-4, feeding a lamb, with brother John, Grandma Amy, sister Amy, and Grandpa Dean.

A few years later, Andrea and her siblings took home lots of awards from the ISF!

Purdue-WHIN Sensors: **Benefitting Farmers, Water Supply**

Nitrates are vital to plant growth. Nitrate fertilizers improves farmers' crop growth and yield, working most effectively when the soil is damp. When soil is too dry, the nutrient is not well absorbed by the crop.

Finding the right balance is key because over-fertilizing is expensive and can negatively impact nearby water sources.

Since early spring, the Purdue-WHIN team has been piloting an innovative solution by installing cutting-edge sensor platforms throughout four farms in Benton County. In addition, Purdue-WHIN is in conversation to expand its project throughout several additional farms in Fountain and Warren counties.

Purdue-WHIN is partnering with farmers in the region to test nitrate levels in the water. This may have a significant impact upon saving farmers money and improving water quality.

The team's sensors measure nitrate levels in field drainage tiles and soil data for the volume of water in soil, along with soil temperature and humidity. All of these are very valuable metrics to farmers because fertilizing and hydrating a farm are both expensive, and the weather greatly affects both.

Through this project, participating farmers provide Purdue-WHIN access to their farm and, ultimately, data that improves their sensors. In return, Purdue-WHIN is providing the participating farmers with a personalized, user-friendly interface that helps the farmers accurately gauge their individual field's nitrate, soil moisture and temperature levels, and other pertinent data.

Although still in the pilot stage, this platform is anticipated to be an extremely effective decision-making tool for farmers striving to plant a successful crop at the most cost-effective price possible.

This relationship extends from a robust partnership with Leslie Fisher of National Resources Conservation Service and watershed coordinator for the Big Pine Creek Watershed Project. Initially launched by the Nature Conservancy, the Big Pine Creek Watershed Project focuses on water quality outcomes from agricultural best management practices throughout a 209,000-acre area in Benton, Warren, White, and Tippecanoe counties. Too much nitrate in the water supply is a health concern.

Although the project is anticipated to expand, Fisher believes even this pilot program will have a very meaningful impact—by both saving farmers money as well as reducing nitrate's negative ecological impact on the water supply. It is well-positioned to provide insights into key questions such as:

- Which method for reducing runoff (such as cover crop, no till, strip till) is most effective, when all other conditions such as soil, weather, etc. are the same? The pilot will be very effective at answering this question since it has two sets of adjacent farms.
- Is it more-cost effective, but equally productive, to fertilize only in the spring?
  - This is a pressing issue since farmers typically fertilize in the fall, then plant and harvest in the spring, expecting the fertilizer's nutrients to be absorbed into the soil throughout the winter. Purdue-WHIN's nitrate sensors are providing valuable data indicating whether this is an effective practice or if a high amount of nutrients are actually lost to runoff during the winter season.

> *We are watching the data that will help make informed farm management decisions. We believe this can help save tons of nutrients in terms of ecological impacts as well as perhaps tens of thousands of dollars per year per farmer.*
>
> – Leslie Fisher

Purdue-WHIN IoT and SMART Films Consortium host SMART FILMS DAY

The SMART Films Consortium hosted a virtual workshop on June 26th, welcoming AeXonis as a new member. Other members include: United Technologies, Sartorius, Bayer, Landauer, and Applied Materials.

Presentations covered condition-based maintenance sensors, Ag soil/water sensors and field testing, electronics, edge analytics, and networking.

Purdue-WHIN IoT activities at the Birck Center were highlighted. A total of 24 attendees from six SMART consortium member companies along with 40 students and faculty participated in the morning event. The SMART films group holds two workshops annually.

Nithin Raghunathan, research scientist and a key facilitator for Purdue-WHIN's nitrate sensor development project and testbed engagement, shares Fisher's enthusiasm.

"The more nitrate that is in the water, the less that is in the soil," said Raghunathan. "This is a financial loss. We can help farmers determine how much nutrients are being lost to run-off."

Another partnership underway by Purdue-WHIN is with Rick Clark, who is a fifth-generation farmer producing corn and soybean on the 7,000-acre Clark Farms in Warren County. Clark uses many practices to rebuild soil organic matter and restore degraded soil biodiversity—a practice known as "regenerative farming."

The Purdue-WHIN team is utilizing sensors to help Clark measure the amount of nitrate in his soil. In addition, the Purdue-WHIN team is exploring the deployment of microbial activity sensor at his property to explore microbial growth in regeneration of nutrients. The sensors on the Clark property will provide an informative comparison between regenerative farming and traditional farming.

On August 28, Clark Farms and the Big Pine Creek Watershed Project hosted an event for other farmers to highlight successful regenerative agriculture systems. Purdue-WHIN's work studying nitrate levels in soil was prominently featured there. WHIN has been a valuable partner, said Clark.

"Our farm is moving away from traditional farming practices, but we still have a good relationship with WHIN," said Rick Clark of Farmgreen.

On-Site Manufacturing Partners: Moving Forward

The Purdue-WHIN team has continued to deploy predictive maintenance sensors with our regional manufacturing partners. Although this work has been impacted during COVID-19, recent progress has included:

- Vibration data are continuously collected from pumps at Purdue's Birck Nanotechnology Center, Bio Town Ag, and Tate & Lyle.
  - Discussions with Evonik, Drug Plastics and others regarding sensor installations have re-started and will expand as campus and companies begin to host visitors once again.
- A dashboard prototype has been developed for real-time data demonstration that is being consolidated to the Purdue-WHIN website.
- A new 0.5 HP induction motor testbed has been designed for implementation and testing of new technologies.

Strengthening Companies: **Building Connections**

Perhaps now more than any time in recent history, many small manufacturing companies are struggling to meet each payroll. COVID-19 has caused uncertainty throughout the economy, hitting small businesses particularly hard.

"The challenge is especially acute for small businesses (those with 500 or fewer employees), which account for a disproportionate share of the vulnerable jobs," states a report released by McKinsey Institute in May 2020. "Before COVID-19, they provided nearly half of all US private-sector jobs, yet they account for 54 percent (30 million) of the jobs most vulnerable during COVID-19."

The Purdue-WHIN Education and Supply Chain teams, in response to COVID-19, have developed a highly valuable website that contains resources to help companies. The resources include white papers, infection control best-practices, and checklists—including downloadable posters. The site is enhanced by an independent SMART Manufacturing Model that looks positively at the opportunities for cost-cutting and increased competitiveness during the pandemic, known as the "TP3 Strategy." Furthermore, the website includes a business process enhancement model that is based upon Value Stream Mapping (VSM) and called VSMI where 'I' stands for 'infection layer.' The VSMI model shows that competitiveness may be enhanced during the pandemic while mitigating the dangers of infection on-site.

In addition, the team has also developed a portal that enables manufacturers to access locally developed inventory quickly and efficiently. The digital Supply Chain Tool (SCT), a web-based portal, is designed to stimulate more local trading, especially Original Equipment Manufacturer (OEM) purchasing and bring more economic success into the region. The team's vision is to encourage local companies to seek out one another for product, services, and potential collaboration. This can be particularly vital as disruptions such as COVID-19 causes supply lines to become less reliable.

The digital SCT enables companies to find one another to help them rapidly purchase goods locally that meet a specific standard. As of March 2020, over 250 local company profiles have been generated within the portal and over 140 have been verified and updated by companies. No advertising is sold on the portal, so all companies know information for each company is presented entirely fairly. Any company in the WHIN region is eligible to join.

INMAC 'Teaser' Workshop Series

The Purdue WHIN manufacturing team through IN-MaC hosted three workshops in July. More than 100 individuals participated in these free workshops. The sessions featured:

IoT and Gathering Data: Profs. Martin Jun and Brittany Newell shared knowledge on: the use of IoT on the factory floor; the identification of potential business impacts; and applying IoT to enhance the capabilities of legacy equipment.

Merging Metrology, Materials, and Model-Based Techniques: Profs. Nate Hartman and Michael Sangid introduced: the flow of product and process information throughout the product lifecycle; and applications to harness data within the digital thread to improve one's ability to make decisions.

Cost Optimization in Robotics and Co-Robotics Driven Production: Profs. Richard Voyles, Jan-Anders Mansson, and David Capelleri provided an overview of available robotic and co-robotic technologies; and introduced techniques to assess the economic impact for various production scenarios.

Strengthening Companies: **Building Connections** *(Cont'd)*

The portal is only one of many ways the team is helping manufacturers throughout the region. The Purdue-WHIN Education and Supply Chain team regularly engages over 50 companies, leading to case-study projects, participation in workshops and conferences, and delivery/presentation on numerous occasions throughout this year—most recently via webinar workshops (see sidebar).

Engagements have led to changes in operating performance, up-ticking in management methods, initiatives to improve recruitment and the on-boarding experience, and to business-to-business activities. These positive projects are further expanding trust with other companies throughout the region. Two case studies below helped showcase how the team has helped manufacturers attract the highest-quality employees are below:

- **Dayton-Phoenix Group (DPG):** Attracting and keeping good workforce is the #1 issue for WHIN companies. Through this case study with DPG, this project has helped showcase how producing an attractive and user-friendly web-based portal improves recruitment. This portal, designed by Purdue students, translates into a digital application that makes it much easier to screen and attract the right candidates and made explicit with short worker-videos providing a way to make the company a more attractive place to work.

  "We really appreciate the opportunity given to DPG with this project, we're already seeing dividends via contacts through the app."

- **Rowe Truck Equipment (RTE):** RTE brought families for a day of interactive and educational fun to find out and be proud of what the employee does for the business. This effort involved families (including 72 children) in the company, with the goal of making staff feel valued, improving staff attendance, and potentially increasing interest among younger family members to work with their parents after graduating. "We would not have thought of it in a hundred years."

  "Thank you for taking your time to provide ideas that may help stimulate interest in small business manufacturing operations like ours."

The Purdue-WHIN Education and Supply Chain teams plays an important role by providing companies with valuable information as well as helping companies learn from one another, say regional manufacturers.

> *"Overall, WHIN creates an effective cadence and atmosphere for the groups to learn from one another."*
>
> – Shain Wells
> Vice President of Manufacturing
> for Wabash National

Workshop: Planning for the New Normal in Manufacturing

The Purdue-WHIN manufacturing team hosted a webinar on August 5 through the Dauch Center for Management of Manufacturing Enterprises (DCMME). Attendance was free. Approximately 40 participants attended.

The topic was, "Planning for the New Normal in Manufacturing, a Workshop Series." This was inspired by a book, "Smart Manufacturing The New Normal: A TP3 Strategy" published by WHIN team members.

Several leaders of WHIN organizations also shared some of the impacts on their operations and how they have adapted their manufacturing environments in light of their recovery efforts beyond COVID-19.

Speakers included:

- Tom Cunningham, Evonik
- Mark Sheets, Frito Lay
- Chuck Hays, Drug Plastics
- Doug Mansfield, Kirby Risk
- Otavio Araujo, Voestalpine
- Prof. Roy Vasher, Purdue
- Prof. Jan-Anders Mansson, Purdue
- Prof. Ananth Iyer, Purdue

GROW and IoT4Ag: **Data-Powered Farming**

Too often, farmers must plan the future of their entire crop, and their entire livelihood, on intuition and observations. A new installable web application, called GROW, has been developed by WHIN-affiliated researchers that can rapidly determine corn estimation for the user's entire farm.

GROW automatically caches satellite imagery, field metadata, and relevant historical weather data, enabling an offline experience. Grower-specific data, such as: field name, boundary, plant date, and variety can be stored privately on a personal Google Sheet allowing farmers to access their field data from any device.

Purdue software engineer Andrew D. Balmos, Prof. Dennis Buckmaster, Prof. James V. Krogmeier, and the Open Ag Technology and Systems (OATS) Center developed GROW to draw information from public weather datasets merged with field boundaries, planting data, and corn variety information. It stores and computes all per-field insights locally, making it accessible out on the farm even when no Internet is available.

GROW, which will soon be released to the public, does not require any server backends other than the Applied Climate Information System's (ACIS) major public weather database from the National Oceanic and Atmospheric Administration (NOAA). The NOAA Regional Climate Centers provides this data free as a gridded map of daily weather metrics. By creating an accessible tool that merges detailed weather data with the farmer's field and planting specifications, GROW improves the farmer's capacity for rapid, informed decision making.

One of the faculty members who helped develop GROW, Prof. Dennis Buckmaster, is also a WHIN member who is part of a $26 million Engineering Research Center grant known as IoT4Ag, awarded by the National Science Foundation to University of Pennsylvania, Purdue University, University of California Merced, and the University of Florida (see sidebar). The IoT4Ag researchers will create miniature soil-based sensors and swarms of aerial and ground-based robots, as well as new ways of networking them together in communication-constrained environments. The researchers will also develop high-level data science techniques that will allow data from different sensors in the field to be integrated with data from weather reports and commodity markets, synthesizing it into actionable information.

"Participation on the IoT4Ag team will leverage Purdue's strengths in developing new engineering technologies that will improve agriculture and address global challenges," said Prof. Mark Lundstrom, acting dean of Purdue University's College of Engineering. "Our involvement will also represent a new chapter in a long history of collaboration between the Colleges of Engineering and Agriculture."

Funding Success: IoT4Ag

The Purdue-WHIN team's Agriculture has had great success attracting major grant initiatives that will be vital in expanding digital agriculture efforts throughout the region. Most recently, this includes being part of a four-university team awarded a $26 million National Science grant to form the NSF Engineering Research Center for the Internet of Things for Precision Agriculture (IoT4Ag).

A five-year grant, ERCs are NSF's flagship engineering programs for convergent research to address large-scale societal challenges. With vital research led by WHIN member Prof. Dennis Buckmaster, the overall mission of IoT4Ag is to ensure food, energy and water security by developing technology to increase crop production while minimizing the use of energy and water resources and lessening the impact of agricultural practices on the environment.

Opening Scheduled for December: **ABE's Extraordinary New Wing**

Purdue's Department of Agriculture and Biological Engineering (ABE) is a point of exceptional pride for the University. Purdue's ABE Department has been ranked #1 in undergraduate schools for nine consecutive years and its graduate program has resided in the #1 or #2 spot for the past twelve years .

Remarkably, this achievement has been accomplished with limited space and resources. Due to space constraints in the ABE Building, the ABE faculty have been spread throughout ten different buildings across campus.

Due in part to a very generous contribution from WHIN, these space constraints will soon be a distant memory. A massive new wing, five-stories plus a basement, is slated to open the second week of December. The ribbon cutting will help launch ABE's centennial anniversary.

The 160,000-square-feet space (see artist rendering below) is designed to be very welcoming to the community. The lower-level floors focus on teaching and applied research. The basement space houses classrooms and teaching labs. As the building progresses higher, the research becomes less applied:

- On the first floor, there is the versatile engagement space, which is anticipated to be highly utilized for hosting companies, events, and showcasing student work. Research space on this floor is dedicated to machinery, sensing, fluid power, and robotics labs. The first floor also houses academic programs for student clubs, resource rooms, and a Copper Moon coffee shop.
- On the second floor, there are computational labs. There is also a glass-walled walkway, providing a view to the event space. This will be extremely helpful when major equipment such as combines and tractors are on display—giving industry visitors multiple perspectives.
- The third floor is home to water and environmental labs.
- The fourth floor is home to bioprocess engineering and food engineering labs.
- The fifth floor is home to biological engineering labs.

Several ABE faculty work extensively in digital agriculture, sensors, food processing and pharmaceuticals—areas of key interest to Purdue-WHIN. ABE Department Head Nate Mosier anticipates many new opportunities for increased collaboration.

> *This new space will open up many new, exciting ways we can work together. This facility is an excellent research, demonstration and learning space. We will have many new ways for working together, back and forth, from basic to applied, to the field to practice.*
>
> – Prof. Nathan Mosier
> Department Head,
> Indiana Soybean Board Professor,
> Agricultural and Biological Engineering

The new ABE Wing is a five-story expansion to the current ABE Building.

WHIN murals capture tradition and history

One of the first grants WHIN made from the Regional Cultivation Fund was to the Tippecanoe Arts Federation (TAF) for a very special public arts project called WHIN Walls. The project, which creates large-scale murals on buildings and other structures in each county, has been one of the most visible ways the general public is connecting with WHIN.

But there is much more to WHIN Walls than its murals, impressive as they are.

Long before the paint is applied, TAF works with each community, sometimes for as long as a year, to find a site, gather ideas from residents about how they want the mural to represent their community, and identify and schedule an artist.

The process involves community, introspection, discovery, and vision, and it requires consensus: all of the skills needed for healthy community development.

Unfortunately, WHIN Walls was yet another initiative that was delayed by the pandemic. Besides the community meetings leading up to creating a mural, artists travel, often from other states, to do the work. They live in the community where they are painting for a week or two. And they interact while they are there, eating in local restaurants and talking with curious residents as they work.

So for most of the long summer months, when painting is ideal, WHIN Walls was on hold. Finally, in late August, the Wolcott project in White County, took shape.

Wolcott has a population of 973. Its main drag is US 24 and the din from passing trucks is constant and deafening. Residents get around town in golf carts, and often parked to watch the artists at work. The mural in the background was part of the project.

The committee that worked on the murals joined artists Nicole Salgar and CERA, TAF CEO Tetia Lee, and funders of the project at the dedication.

CERA, the artist who painted the Dye Lumber mural, noticed this young man, who passed by each day with his Radio Flyer wagon to go fishing. The wagon made it into the mural.

and build community pride

Of all of the symbolism in the mural on the side of the Dye Lumber Building on South Range Street, **Bobbie the Wonder Dog** might be the best known outside of Wolcott! That was certainly the case in the 1920's when the very real Bobbie, a Scotch Collie/English Shepherd, became separated from his family, who was visiting relatives in Wolcott. The family looked everywhere for Bobbie before it was forced to return home to Oregon without him.

Bobbie, however, never gave up. Traveling over 2,500 miles in 6 months, including in the winter, across rivers and impossible terrain, Bobbie found his way back to his owners in Silverton, Oregon. When the story became known, those who had cared for him along the way reached out to the family, enabling the Oregon Humane Society to figure out his route, which corresponded to the family's drive home once he found his bearings. His legs and paws were damaged, but he recovered to fame, starring in a silent film, The Call of the West, about his journey. A children's book about Bobbie the Wonder Dog can be found on Amazon. Silverton has its own Bobbie mural and an annual pet parade is held in his honor. (Wikipedia).

Bobbie's journey—his heart, courage, persistence, and loyalty—resonate not only in Wolcott and Silverton, but during our very difficult times. His story seems an apt way to conclude our highlights.

APPENDIX B: **Outcomes**

Please Note: Due to the connection between projects, there are outcomes listed in the Sensor Development and Implementation section that are also relevant in the Digital Agriculture section. This reflects collaboration, not duplication, of efforts or expenses.

AIM 3.1.1: Establish IoT Platform Testbeds at Purdue to Advance Digital Agriculture Demonstrations, Teaching, and Research

AIM 3.1.1.A: Implement Sensors Within the ABE High-Tech Ag Facility		
Anticipated Outcomes	**Outcomes to Date**	**%**
Due to the construction timeline of Purdue's ABE Building, the ABE High-Tech Agricultural Facility is expected to be widely sensored by 2020 (Year 3, assuming a January 2018 start date). In the meantime, work will begin by investing in a planner/administrator to cultivate industry partnerships, investigate logistics, and train/recruit qualified staff.	• ABE Facility will be open to the public and widely sensored by the end of the year, as scheduled. The 160,000-square-feet space is designed to be very welcoming to the community. The lower-level floors focus on teaching and applied research. The basement space houses classrooms and teaching labs. As the building progresses higher, the research becomes less applied. The ribbon cutting, slated for the second week of December 2020, will help launch ABE's centennial anniversary. Classes will commence in this high-tech ABE facility in January 2021.	90%
Twenty demonstrations and/or teaching initiatives per year.	• In spring 2020, Purdue enrolled 134 students in digital agriculture-related courses, including: Design of Electronic Systems (ABE 314) with 21 students, Environmental Informatics (ABE 65100) with 31 students, Ag Systems Computations and Communications (ASM 10500) with 42 students, Electric Power and Controls (ASM 42000) with 32 students, and Advanced Machine Technology for Agricultural Crop Production (ASM 42200) with 8 students.	100% of target (60% of goal over 5 years)
Proposals submitted for three community-linked research projects connected with the facility per year, post sensor installation.	• Living Lab funding that originally supported this outcome is being directed by the WHIN Administration.	0%
Two new technologies/intellectual property filings per year generated by the testbeds, which will result in new startups and products launched in the WHIN region.	• Dr. Chaterji has filed two patents with the Office of Technology and Commercialization (OTC) and published two papers in July describing her efforts. Both technologies are open for licensing through OTC. - **Technology #1:** On-premise NoSQL database configuration (known as Sophia). Sophia increases the economic lifecycle of databases through a Cost Benefit Analysis (CBA) coupled with a Reconfiguration Plan, implements intelligent incremental reconfigurations, and predicts future workloads up to an hour ahead using a Workload Predictor, thereby optimizing throughput. In addition, the Sophia program will initiate reconfiguration only when it estimates the benefit over a future time window is higher than the cost of the reconfiguration. - **Technology #2:** Cloud-hosted NoSQL database configuration (known as OptimusCloud). OptimusCloud jointly tunes cloud virtual machines (VM) and DBMS levels to optimize database performance while minimizing the cost. Current cloud technologies using automated decision making, often only working for short and repeat tasks and workloads. This innovation can create the optimal configuration to handle long running workloads where the workload characteristics change over time (as is typical in IoT workloads or e-commerce sites).	100%
$3.5 million of research expenditures in the testbeds from industry and government sources, post-sensor installation.	• No research expenditures in the testbeds from industry and government sources to report in this six-month period.	1%

AIM 3.1.1.B: Implement Sensors Within the Indiana Corn and Soybean Innovation Center, Located on the Agronomy Center for Research in Education's (ACRE) Farm

Anticipated Outcomes	Outcomes to Date	%
Purdue's ACRE Farm site is expected to be extensively instrumented by late 2018 (Year 1, assuming a January 2018 start date).	• Continued ISOBlue development with more than ten units deployed to capture full CAN streams from vehicle and implement buses. Analytics of that data is in process with one publication submitted, another near submission.	100%
Twenty demonstrations and/or teaching initiatives each year.	• Despite the complications of COVID-19 and the restrictions on in-person gatherings, 470 presentations, 57 demonstrations, and 13 programs were delivered between March 2020 and August 2020. • As part of the Open Ag Technology and Systems (OATS) Center outreach and education, a few faculty, staff, and students gave some presentations to the AgGateway community. COVID-19 has impacted progress of the Ag Gateway project (https://ag.purdue.edu/digital-ag-resources/aggateway-posts-educational-videos-python-blockchain-rural-networking/) because of a complete shutdown of in-person research for a couple months followed by necessary research protocol filings in order to get back on-site. Progress continued in learning about the Microsoft FarmBeats system, but work with physical units could not resume until August 2020.	95%
Proposals submitted for three community-linked research projects connected with the facility per year, post sensor installation.	• Living Lab funding that originally supported this outcome is being directed by the WHIN Administration.	50%
Two new technologies/intellectual property filings per year generated by the testbeds, which will result in new startups and products launched in the WHIN region.	• Microsoft provided Azure credit and a cash contribution toward FarmBeats deployment and improved machine data collection. Deere has a project with Drs. Evans, Lumkes, and Vyn. Infosys, Microsoft, CNH, and Winfield remain director level members of the Open Ag Technology and Systems (OATS) Center.	60%
$2 million of research expenditures in the testbeds from industry and government sources, post-sensor installation.	• An additional $20,000 gift from Microsoft is pending. Continued conversations with potential partner companies such as Iyotah. FarmBeats installations have been stalled due to COVID-19 restrictions.	28%

AIM 3.1.2: Establish Sensors Throughout the Ivy Tech Community College – Lafayette Agriculture Teaching Laboratory

Anticipated Outcomes	Outcomes to Date	%
Ivy Tech Community College–Lafayette Agriculture Teaching Laboratory will serve as a testbed and be widely sensored by 2019.	• The RealmFive company has installed a LoRaWAN compatible weather station within the Ivy Tech testbed, the first in the 10-county WHIN region. In addition, there was an installation of a "flex" model moisture sensor, which communicates with the LoRaWAN weather station as a gateway. A sub-surface "furrow" model soil moisture sensor to be placed 12 feet underground will also be installed in September. Ag industry partners in the region are highly interested in these technologies.	100%
Ivy Tech will develop campus-based curriculum, and work in conjunction with the Krannert School of Management and IN-MAC, in developing online curriculum.	• In August 2020, 10,000 of Ivy Tech's free online course offerings were integrated into the Purdue Education Portal, which is a project of the Krannert School of Management. The courses are continuously updated to allow the Portal to remain current during the COVID-19 pandemic.	95%

AIM 3.1.2 *(Cont'd)*		
Proposals will be submitted for four community-linked research projects connected with the laboratory per year, following the sensor installation in conjunction with Purdue University.	• WHIN and Ivy Tech were recently awarded a $50,000 grant from the Indiana Office of Energy Development (OED) through their Rural Energy Innovation grant program. This two-year grant will involve the deployment of IoT-based energy monitoring devices on manufacturing floors to determine power quality and monitoring on individual pieces of equipment and throughout the facilities. The data collected from these systems will be analyzed by engineering consultants, and power management plans will be provided to the manufacturers. Ivy Tech faculty will utilize this data and real-world power management plans to create curriculum to be used in the Advanced Manufacturing courses. • A collaborative proposal was submitted in July 2020 with the Purdue Department of Agronomy and the Ivy Tech Precision Ag Equipment Technology program to the USDA NIFA Workforce program is in process. If funded, the project will assist with creating curriculum for train-the-trainer programs with high school teachers teaching precision agriculture in their programs.	100% of target (42% of goal over 5 years)

AIM 3.1.3: Establish IoT Testbed(s) Throughout the Wabash Heartland Region with Industry Partners		
Anticipated Outcomes	**Outcomes to Date**	**%**
Three of the community-based research projects above will be community-linked IoT platform/research projects each year, after sensor installation in the Purdue testbeds.	• In the past six months, the WHIN Administration has deployed 28 weather stations and finalized the configuration of the Sol-Chip POC Weather Station (a LoRaWAN solution), making for a total number of 75 weather stations installed.	40%
Ten counties throughout the region will be engaged each year in community-linked IoT platform projects or training.	• WHIN has deployed digital agriculture technology through its Tech Partners (Solinftec, RogoAg, Telesense, and Intelinair) for Ag Alliance members. • WHIN has deployed digital manufacturing technology through its Tech Partners (Fluke and Guardian Protections Services) for Manufacturing Alliance members. • WHIN is partnering with WATCH Communications and RTO Wireless for the Broadband Alliance. • WHIN continues to work with Purdue to engage agriculture-related stakeholders for R&D projects such as nitrate sensors.	60%
$.5 M of research expenditures in the testbeds from industry and government sources.	• WHIN has received investments from Tech Partners totaling an additional $210,245 in this six-month period for a grand total of $771,153.	100%

AIM 3.1.4: Develop "Career Ready" Educational Programs in Applied Data Analytics in High-Tech Agriculture: Providing Middle-Skills Certifications, Undergraduate, and Graduate Education		
Anticipated Outcomes	**Outcomes to Date**	**%**
A full-time educational specialist that leverages opportunities between Purdue and AgriNovus.	• Purdue-WHIN digital agriculture team was funded as part of the IoT4Ag NSF Engineering Research Center and Testbed (https://www.nsf.gov/news/special_reports/announcements/080420.jsp). The Center, specifically targeted for the Internet of Things for Precision Agriculture, seeks to ensure food, energy, and water security with new systems to increase crop production while minimizing energy and water use and environmental impacts of agricultural practices. The Center involves four partner universities: University of Pennsylvania (lead); Purdue University; University of California, Merced; and University of Florida. AgriNovus was consulted previous to grant submission. • "Heat Units: A Python Tutorial" talk was presented at the 2020 Ag Gateway virtual conference. The talk walks through using public weather data to make decisions based on growing degree day accumulations for a field at ACRE.	100%

AIM 3.1.4 *(Cont'd)*		
Twenty-five BS graduates per year in digital agriculture.	• Thirteen more students graduated in June 2020 with a BS that included at least four digital agriculture courses, bringing the total to 43 to date. • Another digital agriculture course, Data Science for Agriculture (AGR 33300), was launched this fall 2020. • ABE 591 was offered as a one-credit special offering to teach machine learning for genomics and IoT. • Many courses were completed successfully despite COVID-19 disruption.	100%
Fifty certificates per year awarded on digital agriculture topics.	• Thirty-two certificates issued to adult learners in May 2020 for the UAV operations (AGRY 598) course instructed by John Scott. Sixteen certificates were awarded to adult learners who successfully completed the spring 2020 offering of Precision Agriculture, one of the four courses in the Agronomy e-Learning Academy.	100%
Eight professional MS degrees per year awarded in digital agriculture.	• Fourteen students graduated in June 2020 with an MS or PhD that included at least one digital agriculture course.	100%
Twenty-five positions filled in critical needs areas (projected from baseline occupational skills needs assessment).	• Based on the count taken from WHIN's Midpoint Economic Impact Analysis, 23 positions in critical needs areas were filled in 2019 and 2020 through WHIN's tech partners and Ag and Manufacturing Alliances.	92%

AIM 3.1.5: Develop Extension Programs to Strengthen the Purdue Extension Program's Ability to Serve Agricultural Producers and Agribusinesses in the 10-County Region with Regard to "Digital Agriculture"		
Anticipated Outcomes	**Outcomes to Date**	**%**
A full-time extension specialist coordinating the outreach work of the Purdue team involved in the deployment of "digital agriculture" strategies relevant to the region.	• The full-time Purdue Extension specialist, John Scott, is developing a digital agriculture app database with a goal of having 500 available apps listed when it goes live. The database will be searchable to give researchers, educators, producers, and the ag-interested public a starting place for selecting an app they want to use. Scott participated on a team of Extension Educators from across the state to develop a digital agriculture curriculum, where he was responsible for creating the Programming, Internet of Things (IoT), Precision Equipment Electronics, and Data Management units. Due to COVID-19, there have been fewer in-person meetings/field days, so Scott used the time to focus on collecting more data in the field than what would normally be possible due to time constraints. The goal is to use this data to help local producers as they go about the business of farming and to also help show producers how data can be leveraged on their own operations in future partnerships.	100%
Investment in a marketing campaign to brand Purdue Extension as the primary and trusted source of information on science-based digital agriculture innovations.	• Developing virtual experiences for 4-H, FFA, and other high school students related to advanced technology or agriculture. • Purdue-WHIN faculty, Bruce Erickson, was featured in CropLife Magazine's as the cover story in July 2020: Moving the Needle on Decision Agriculture (https://www.croplife.com/precision/2020-precision-ag-dealership-survey-moving-the-needle-on-decision-agriculture/#Tinsel/83847/1). • Purdue Online is integrating the Precision Agriculture course and other Purdue Agronomy e-Learning courses into its marketing plan. Erickson continues his role on the Purdue Online advisory committee, with much activity recently related to course delivery, student and company needs in light of COVID-19. IoT for Everyone video series (https://ag.purdue.edu/digital-ag-resources/iot-for-everyone-videos-tutorial/) was completed in August 2020.	75%
Development of a suite of 15-20 extension-related products that inform, educate, and increase access through Purdue Extension channels (such as the Purdue Extension website and the Education Store).	• A new installable web application, called GROW, has been developed by Purdue-WHIN-affiliated researchers that can rapidly determine corn estimation for the user's entire farm. WHIN-funded Purdue software engineer Andrew Balmos and Dr. Dennis Buckmaster, along with Dr. James Krogmeier, created GROW to draw information from public weather datasets merged with field boundaries, planting data, and corn variety information. It stores and computes all per-field insights locally, making it accessible out on the farm even when no Internet is available.	75%

AIM 3.1.5 *(Cont'd)*		
Adoption of digital agriculture strategies by at least 15 rural communities, agribusinesses, co-ops, and/or ag-related nonprofits by 2022.	• During this six-month period, there were active digital agriculture engagements in Benton, Carroll, Clinton, Tippecanoe, Warren, and White counties. Research regarding dairy feeding and intake analytics is ongoing with Benton Dairy, in collaboration with Iyotah and Purdue-WHIN faculty. One Carroll County producer is considering UAV as an option for monitoring crop development. • On-farm, farmer-driven trials protocol meetings were held in Clinton and Tippecanoe counties. Four producers in Benton County and one in Warren County are testing Purdue-developed sensors.	60%

AIM 3.2.1: Establish a Testbed to Demonstrate, Teach IoT to Companies and Students		
Anticipated Outcomes	**Outcomes to Date**	**%**
Design and plan Intelligent Manufacturing Testbed (IMT) physical location at the Indiana Manufacturing Institute (IMI) in Purdue's Research Park.	• Initial Testbed capabilities and infrastructures are complete and operable. The public launch planned for March 2020 was cancelled due to the emergence of the new coronavirus. Even so, the Testbed facility quickly pivoted its operations to provide essential value to the WHIN community and State of Indiana by becoming Purdue's hub to rapidly prototype, manufacture, and distribute more than 65,000 critical PPE to backstop critical supply chains for hospitals, first responders, and care providers. As COVID-19 subsides Testbed operations to manufacture more traditional products and host WHIN companies directly will be restored. A public re-launch event is anticipated in early 2021.	100% of target (80% of goal over 5 years)
Establish IMT Testbed to showcase IoT sensor/network capabilities to companies and students.	• Testbed sustainment plans include its utilization as a space for leading research in advanced IoT sensor, network and information integration, plus the engagement of leading industry service providers to partner with Purdue in developing opportunities to service the needs of manufacturers. • Strategic relationships with industry service providers aid in connecting IMT capabilities and resources to manufacturers across WHIN and beyond. These relationships include: Hexagon/eXstream, Sage Clarity, Haas, Flexxcool, and Kennametal. Relationships with Haas, Flexxcool, and Kennametal have advanced in the past 6 months. The collective value of discounts, gifts, and services from industry partners during grant year three exceed $135,000.	100% of target (60% of goal over 5 years)
Establish additional technology adoption opportunities through mobile demonstrations.	• WHIN-Manufacturing (through IN-MaC) began to pilot a Manufacturing Improvement Service (MIS). The MIS provides technical assistance to companies who are looking to add or expand in-house machining capabilities. These services provide advanced machining and production optimization assistance. IN-MaC has received enthusiastic feedback from its first industry participant (Engineering Improvement Services, Inc.). Proceeds from MIS projects will be applied towards IMT sustainment. In addition, a new TAP40 project has been initiated with Voestalpine.	100% of target (60% of goal over 5 years)

AIM 3.2.2: Establish a Testbed to Showcase Real-Time Sensor and Network Capabilities of WHIN-Area Firms for Original Equipment Manufacturers (OEMs)		
Anticipated Outcomes	**Outcomes to Date**	**%**
Identify a relevant use case for demonstrating connectivity between OEM and supplier for design, production (including supply chain), and sustainment.	• The Testbed wields a suite of digital and cloud-based tools and applications within its digital architecture. Researchers have discussed several scenarios with manufacturers; however, none have been willing to commit at this scope. Data gathering from production facilities, and using that data to build predictive models, has proven of more interest to WHIN-region manufacturers. The research team has identified and studied a number of use cases through a product lifecycle based on projects with OEMs and their suppliers. Work to integrate and manage digital information streams from a variety of commercial and custom tools and applications remains a core focus of work in the IMT.	80%
Deploy commercial software, hardware, and middleware, establishing the IMT digital sensor and networking architecture, between laboratories on West Lafayette campus for prototype workflow/infrastructure.	• In collaboration with the WHIN-IoT group, WHIN-Manufacturing researchers continuously collect environmental data (temperature, humidity, air pressure, fan vibration) from Birck through network capabilities. Further, the WHIN-IoT and WHIN-Manufacturing groups continue to collaborate on IoT sensing of a manufacturing system in the Testbed (environmental, fluid flow, power consumption) through wireless and remote capabilities. • Collaborations with researchers from the FLEX Lab applies IMT network capabilities and middleware technologies to couple sound-based sensors to equipment running in the Testbed. Data collected feeds algorithms that allow researchers to study machine status and operating conditions. This work influences machine learning models and the generation of digital twins.	100% of target (60% of goal over 5 years)
Finalize satellite locations for IMT architecture at companies throughout the WHIN region.	• On-site sensors and instrumentation from manufacturers throughout the WHIN region continue to feed valuable data to researchers that will be applied to develop technologies and methods for industry. WHIN-Manufacturing researchers have conducted field work at 11 WHIN companies, including testbeds that remain active at: Drug Plastics, Standard Industrial, Tate & Lyle, Oscar Winski, EIS, BioTown Ag and Voestalpine.	100% of target (60% of goal over 5 years)
Deploy and assess the digital product and process information model with partner companies and their supply chains.	• Exercise middleware technology (MTConnect) for the generation of digital twin at Standard Industrial in Pulaski County.	80%
Have deployed full digital enterprise sensor and networking architecture and infrastructure within the IMT location.	• The network architecture for the IMT is established. Several secure private subnetworks specific to research activities at IMT are established. The IMT includes a range of CAD, PDM, MES and ERP solutions, and has several IoT sensors deployed. Researchers actively study the barriers to digital interconnections across the Testbed and will continue to do so as additional informational technologies, middleware, and IoT solutions are deployed.	80%
Develop prototype predictive analytics architecture and tools.	• Predictive analytics tools and methods have been studied through a number of projects both at Purdue and from companies across the region: a) Vibration data are continuously collected from pumps at Birck, Bio Town Ag, and Tate & Lyle; b) Researchers developed a prognostic model to predict remaining useful life of the pumps in Birck. The developed model will be deployed for real-time monitoring. c) A temperature monitor module has been established via LabView and it will be added to the Birck pump prognostic model. d) Researchers and staff from WHIN-IoT and IMI are collaborating to study applications of low-cost sensors for subtractive machine monitoring. The study will monitor energy consumption and vibrations at primary motors, flow rate of cutting fluids, and the quality (conductivity) of cutting fluids. Data collected will be assimilated with dynamic tooling rates and forces, tooling probe calibration, downstream geometric part verifications, and environmental data (temperature, humidity). Sensors developed by the Birck-WHIN team have been mounted to the CNC machines and data pathways are established.	100% of target (60% of goal over 5 years)

AIM 3.2.3: Establish a Digital Supply Chain Tool to Increase the Visibility of WHIN's IoT Capabilities to Procurement Managers Discover WHIN-Area Firm Capability		
Anticipated Outcomes	**Outcomes to Date**	**%**
Map the capabilities of companies in the WHIN region using digital tools for supply chain prototyping.	• Due to COVID-19, no new contact was established with companies to map their capabilities in April and May 2020. In June 2020, outreach resumed with the intent to explore solutions for their safe reopening. At this time, more company information in the supply chain database was validated and updated. In July 2020, new company attributes and certification categories were added to the database along with six new company profiles.	60%
Connect with LEDOs or other economic development groups across WHIN counties to deploy supply chain prototyping tool.	• Developed relationships with LEDOs from an early stage in the project with many face-to-face meetings and partnerships to attract local companies. Included other economic players in the WHIN region, such as leading agents in the Chambers of Commerce. Introduced LEDO representatives to other economic agents and updated them regularly on progress so they could leverage activities and resources for the benefit of regional companies.	95%
Work toward expanding the Digital Supply Chain Tool to include specialized suppliers.	• Analyzed 250+ companies in the Digital Supply Chain Tool (DSCT) database to identify each company's specialty based on the following four categories: - OEM = Original Equipment Manufacturer - Production Supplier = Suppliers that make production parts - MRO Supplier = Suppliers that make maintenance and repair products - Service Providers = Companies that provide services such as: repairs, janitorial, maintenance, etc.	40%
Work with OEMs to prioritize approaches to reduce supply chain leakage and record extent of leakage reduction.	• Conducted a survey across the counties recording what difficulties are being faced by the WHIN companies. Provided them with the survey results, as well as suggestions for how they can survive/ thrive through the pandemic. In late August, started to introduce OEMs to the Digital Supply Chain Tool (DSCT). OEMs are shown specific product components that they are importing by volume and weight, and then they search the DSCT to identify local suppliers that could help them to re-shore and achieve faster and cheaper delivery times.	95%
Work with individual companies to seek opportunities to collaborate to go after new business.	• More than 40 highly-engaged companies have been very regularly in contact with the Purdue-WHIN team. Companies are taking advantage of the entire resource package, including: workshops, conferences, training, webinars, visits, shared case-study-projects, regional, corporate (non-competitive) development meetings, Special Interest Group meetings and site-tours/meetings.	95%
Expand deployment of supply chain prototyping tools at LEDOs or other entities.	• Deployment of the updated Digital Supply Chain Tool (DSCT) began in August 2020, resulting in several success stories: a) A WHIN company could not find a 50-ton mobile crane in the region but found one within six miles after making a contact at a regional meeting. b) A WHIN company needed surface-active cleaning treatment to prevent virus x-infection and was introduced to a local supplier immediately. c) A WHIN company was interested in exploring global reach for their products--and DSCT facilitated an early introduction with a local automotive OEM. d) An incoming corporate wanted to establish the local sourcing of components in order to invest in Lafayette, and the DSCT was able to very quickly provide many local contacts to encourage the company to grow a local business.	95%
Deploy supply chain prototyping tools as Web-based resources to attract new manufacturing investments to the WHIN region	• The DSCT was revised in order to provide more flexibility for search options. In addition, 12 months of import data has been purchased to assist OEM's with identification of imported parts that may be candidates for localizing, as well as identifying local suppliers that may have capabilities.	50%
Work with procurement managers at OEMs to implement usage of supply chain prototyping tool.	• Published new website that will educate WHIN companies on manufacturing guidelines for crisis management.	50%

AIM 3.2.4: Establish the Ivy Tech Next-Generation Center Pilot Program

Anticipated Outcomes	Outcomes to Date	%
The first year of the grant will be focused on fostering greater collaboration between Ivy Tech and Purdue in terms of IoT expertise and student need assessment.	• Close collaboration with Purdue and Ivy Tech has become an impactful outcome from the WHIN relationship. As the testbeds are created in close collaboration, so are the opportunities for students at both institutions to learn from various IoT systems. This also includes dataset collaboration to use in courses for analytics experience. The Ivy Tech students in the IT programs will be looking at these large, raw data sets beginning in the Fall of 2020.	100%
Year 2 will be focused on recruiting students and setting up the sensored lab in preparation for the pilot.	• ROGO Ag is a WHIN tech partner, which is a robotic soil sampling company. Plans are underway for students in the AGRI 219 Crop Machinery and Equipment and AGRI 220 Applied Agronomy courses to witness the set up and deployment of precise soil sampling in the farm field. • Solinftec will be demonstrating and beta-testing their plant phenomics measuring technology at the Ivy Tech Ag Teaching Laboratory. They will be monitoring the phases of plant growth and maturity on a weekly basis. This device is a robotic technology, which moves throughout the farm field taking leaf measurements. This will be available to students enrolled in several different courses within the Precision Agriculture Equipment Technology program. Across these Agriculture programs, there will be an anticipated 45-50 students exposed to farm sensor technology through coursework/farm tours.	95%
Years 3 and 4 will be implementation-focused, working with 80 Ivy Tech students per year, spanning several disciplines in agriculture and manufacturing (for a total of 240 students in Years 3-5).	• In July 2020, a substantial purchase was made for the manufacturing testbed for training students in mechatronics. The Amatrol Mechatronics Trainer will enable students and industry partners to train their employees in several facets of a smart factory. The estimated number of students impacted per semester in the manufacturing lab will be approximately 30. An additional trainer unit to demonstrate three sensor technologies in the manufacturing space will be deployed and used during the fall 2020 semester. These IoT sensors measure optical distance, infrared heat detection, and inductive proximity sensing. This will expose an additional 15 students to these sensor technologies.	55%
A minimum of 20 students will participate in summer internships during years 3-5 (located at both the Ivy Tech and Purdue University campuses), stemming from the pilot program.	• Ivy Tech hired four interns during the summer of 2020. The interns worked together as a team, and collaborated in a virtual setting during the COVID-19 pandemic. The students were from both Purdue and Ivy Tech, and they assisted with the development of the Ag and Manufacturing Testbeds, as well as with the WHIN weather station network. They conducted applied research in the area of identifying digital agriculture resources available to the farmers of the WHIN Ag Alliance, and they completed database management tasks to support the WHIN Purdue Education Portal project. In addition, they provided temporary broadband connectivity for the Benton and Fountain county fair activities, in order to facilitate social distancing for community members to view live-streaming of 4-H youth events at the county fairs remotely. Several of these interns will continue the roles into the fall of 2020.	40%

AIM 3.2.5: Establish Workforce Engagement and Training for Smart Manufacturing and IoT

Anticipated Outcomes	Outcomes to Date	%
Reach out to all 77 manufacturing companies identified in the region (during Year 1), targeting five-six consultations per month in order to visit all of them within the first year, if possible.	• During this crisis period, DCMME attempted to contact 80 companies regarding COVID-19 information and supply chain profiles. Results were: 42 new email contacts, 10 no longer in business, two not located in WHIN counties. Voice mail messages were left; DCMME will follow-up after companies restart business. Most recently, 30 employees from WHIN region manufacturers attended two virtual workshops conducted in August 2020.	100% of target (50% of goal over 5 years)
Use the gap analysis process to develop customized courses (aggregated as company needs align) to help build the capacity of their employees to increase their "value creation ability" by using IoT and related smart tools (during Years 1 & 2).	• Developed a range of short courses to meet the gap-analysis needs of about 100 local companies. These needs cut across technology, management and training, systemization, and product management. Courses are often web-based, but Digital App short courses were also developed to meet regional needs.	95%

AIM 3.2.5 *(Cont'd)*		
Implement communication plan that includes WHIN web-site and periodic newsletter.	• Produced newsletters and more recently, shorter 'bulletins' to provide free solutions that can be rapidly deployed and to expose other resources in the Purdue-WHIN platform to view. In the last six months since launch, an aggregate total to nearly 2,000 (live) CTRs (Click-Throughs) have been counted. As a response to the pandemic, the Purdue-WHIN team independently published a book, SMART Manufacturing, The New Normal – A TP3 Strategy, to support manufacturing businesses. Local companies were provided free copies of the publication • Produced attractively-designed and practical posters that are freely available printed or as digital downloads, addressing the manufacturing 'gaps' and now include infection control measures.	95%
Design curriculum around the content most needed by employees (as exposed in the gap analysis) to increase their "value creation ability" and productivity.	• Created 16 new courses that comprise the 'Frontiers in Technology' offering. These will be available free to WHIN regional companies and workers and will help them become inspired by technological application in manufacturing industry. LEDOs have been trained in the use of the DSCT, as well as the TP3 tool for OEM re-shoring and local supplies switching discussed in the latest publication.	95%
Engage with LEDOs and individual companies on a regional basis to promote education programs and encourage small project co-learning. Select companies, based on the results of the gap analysis, that are interested in the work and are a good fit for the project.	• Most recently, LEDOs were introduced to Purdue-WHIN supply chain initiatives. Thus, many of them should be able to demonstrate how to use the Digital Supply Chain Tool (DSCT) to assist larger companies to source local suppliers and to help smaller suppliers of goods and services to collaborate in order to meet customer needs.	95%
Select companies, based on the results of the gap analysis, that are interested in the work and are a good fit for the project.	• The Special Interest Groups are non-competitive company groups that share on a focused-need basis. Their focus has been on subjects relevant to local needs as identified explicitly in our gap-management survey of about 100 local companies with inputs from other stakeholders, partners and subsequent engagements with the companies themselves. During COVID-19, the groups' focus has shifted towards managing the crisis.	95%
Determine the best delivery system suited for the audience(s), adapt how the course is delivered (in person, online or hybrid).	• Special Interest Groups and Regional Development Groups have been meeting for almost two years (December 2018) covering subject matter such as 5s, SMART Technology, metal additive technology, staff-retention best practices, and business accounting to mention just a few of the myriad of needs that we provide resources for.	80%
Arrange a training schedule based on company/employee needs (assessing opportunities for training at shift change, worker needs like transportation and childcare, and availability).	• The Regional Development Groups, four groups that meet across the ten counties, are facilitated and supported by the Purdue-WHIN team's expert knowledge based on practical experiences in major manufacturing corporations. During the pandemic, these have taken a back seat to live meetings, but companies are still engaged with in multiple ways from projects to case-study collaborations to workshops and conferences (pandemic and subject-specific), often as contributors.	60%
Deliver courses, on an as-needed basis, on-site at the manufacturing plant to current employees (Years 2-5).	• Most recently, a VSMI course (where VSMI stands for Value-Stream Mapping Infection Layer) and Multi-Tasking Certification Instrument (MTCI) were delivered to fulfill the needs of local companies in the face of the pandemic. The MTCI helps companies to manage the constant issue of people not turning up for work and needing the right skills in the right places.	80%
Engage at least 30% of the 77 companies (for a total of at least 25 companies implementing/operating courses designed and deployed by DCMME) (by the end of Year 5).	• DCMME documented over 2,000 engagements with WHIN companies (in the form of consultations and small projects) within the last three years including at least 200 site visits during the same period.	100% of target (50% of goal over 5 years)

AIM 3.3: IoT Infrastructure and Data Analytics – Digital Ag Sensor		
Anticipated Outcomes	**Outcomes to Date**	**%**
Study the field data from soil sensors (nutrients, moisture, temperature) to study aging, drift, biofouling.	• Improvements were made in the reference electrode and packaging in order to increase stability and longevity of the nitrate sensor. A total of 50 fully-packaged nitrate sensors were prepared for deployment. A prototype circuit was also developed for interfacing an impedance converter and a multiplexer, paving the way for multi-sensing capability.	100%
Fabricate two dozen sensors for lab characterization and field test.	• Around 1550 electrodes were fabricated (each nitrate sensor has a reference and a working electrode). From those, around 580 electrodes were imaged inline and the thickness was captured for around 395 electrodes. Additional imaging and analysis were performed for approximately 340 electrodes. To further improve the quality and consistency of our manufactured electrodes, coating equipment was moved to the cleanroom, where the levels of humidity, temperature, and ambient particles are highly controlled.	100%
Finalize the design of water sensors for Purdue's Water Quality Field Station.	• During this period, 188 nitrate electrodes of various configurations were tested, evaluating drift, aging, and sensitivity to various nitrate concentrations over time periods spanning between ten hours to a week. Using the same conditions, 14 fully-packaged nitrate sensors were tested in field deployments. The field data are being used to improve machine learning models, which will ultimately compensate for sensor variability and aging.	100%

AIM 3.3: IoT Infrastructure and Data Analytics – Next Generation Manufacturing Sensor		
Anticipated Outcomes	**Outcomes to Date**	**%**
Study the field data from distributed temperature, humidity and moisture sensors.	• Performed validation and testing of the manufacturing sensors (including vibration, pressure, temperature, and humidity) at lab setups, as well as industrial installations available at the Birck Nanotechnology Center. These studies identified areas for improvement (e.g. signal-to-noise ratio and immunity towards environment interference), and the necessary upgrades were performed as a result. In addition, testing of custom flexible vibration sensors has begun in order to provide a low-cost, high-performance, scalable solution to the monitoring of a long manufacturing line.	90%
Study aging and drifts.	• A total of 16 setups were tested with MEMS vibration sensors, and two setups were tested with custom flexible vibration sensors. These measurements were done over wired and wireless (Bluetooth) connections. LoRaWAN-based, three-phase current meters were also tested in three different installations. The purpose of the tests was to optimize sensors' signal-to-noise ratio, assess our custom devices, and improve the robustness of the wireless communication.	80%

AIM 3.3: IoT Infrastructure and Data Analytics – Communication and Networking		
Anticipated Outcomes	**Outcomes to Date**	**%**
Evaluate communication fidelity and data security.	• A local LoRaWAN network server, as well as an additional server, have been added for the dynamic visualization of the sensor data with user-control access. With deployments at IMI and the Birck Nanotechnology Center, the capability of installing and visualizing commercially-available LoRaWAN devices now exists, in addition to our LoRa/LoRa-mesh custom sensors. The web portal has been updated with more user-friendly graphing capabilities, faster interface, and ability for user-authentication in order to access specific nodes. Furthermore, receiver scripts have been updated in order to provide cross-version compatibility, supporting also the latest deployments of the commercially designed and packaged (IP68-rated) IoT nodes.	100%
Implement edge analytics, security and machine-learning to improve the design of reliable and robust sensors.	• The integration of a window forecasting algorithm has been completed in both the firmware of embedded nodes and the software of receivers for the BLE-based vibration-sensing modules. The algorithm allows for prediction of acceleration values at the receiver, reducing the bandwidth required for reconstructing the full frequency spectrum. On the ag side, image-based machine learning prediction of nitrate sensor performance has been improved by including a new crop method to exclude edge artifacts in images of the sensor electrode, as well as an enhanced local binary pattern to quantify sensor morphology.	80%

AIM 3.3: IoT Infrastructure and Data Analytics – Field Data from WHIN Region		
Anticipated Outcomes	**Outcomes to Date**	**%**
Obtain field data from 12 IoT nodes from region. Sensor network at 15 locations (farms, manufacturers, public buildings).	• Agricultural IoT networks were added at four sites in Benton County, out of which three are currently collecting nitrate concentration, temperature, humidity, and soil conditions. An agricultural IoT network was also added in Warren County, which is reporting nitrate concentration, temperature, and humidity conditions. Furthermore, existing deployments (e.g. at Ivy Tech Community College, TPAC, and ACRE) were upgraded, adding new sensing nodes. Performed visits at Evonik for assessment of the installation conditions and visits at Drug Plastics and Glass Co., Inc. in Benton County to plan deployments of vibration sensors.	90%

AIM 3.3: IoT Infrastructure and Data Analytics – Education Program, Guest Lectures		
Anticipated Outcomes	**Outcomes to Date**	**%**
Guest lectures (K-12, community colleges, local businesses).	• The IoT Infrastructure and Data Analytics team participated in the Virtual SMART Industry Meeting on June 26, 2020, which included more than 20 company participants. During the meeting, PIs and students presented the latest achievements and described our progress on the goals of the WHIN project. We also participated in the Regenerative Systems Deconstructed event by the Big Pine Creek Watershed Project in partnership with Clark Farms in Warren County, which was held on August 28, 2020, and was organized by the Benton County Soil and Water Conservation District. During the event, which was attended by 150 in person and virtually by hundreds of farmers, Purdue-WHIN demonstrated its latest precision agriculture advanced IoT devices and machine-learning technologies.	100%
Help community testbeds with IoT sensors, data network, and data analytics	• Measurements are currently being analyzed from the custom nitrate and commercial soil sensors at the agricultural nodes deployed in Benton County. Measurement reports will utilize adjacent weather stations and environmental sensor data to provide soil and nutrient information, as well as observed correlations in data that can be useful to compare different farming practices and eventually reduce nutrient loss and water pollution.	80%

AIM 3.4.1: Build Capacity and Connections Through RFPs		
Anticipated Outcomes	**Outcomes to Date**	**%**
There is better collaboration between public and private entities in the region--and a net increase in financial and social capital.	• In the past six months, WHIN staff members have reached out to regional public and private entities in these ways: - Partnering with regional manufacturers via WHINsource and weekly huddle - Watch Communications/regional LEDO meeting to communicate broadband projects - Community Foundation Directors meeting to discuss regional IoT opportunities - Broadband Alliance initiative - Ag Alliance initiative	50%
There is better alignment between regional education and workforce efforts, yielding more youth and adults prepared for employment.	• WHIN Tech Partner, Intelinair, hired four account managers and one agronomist in the WHIN region to meet the needs of the Ag Alliance partnership. • WHIN has partnered with Purdue's Data Mine so that 600 undergraduate students can utilize the weather station data set.	55%

AIM 3.4.2 : Educate the Region's Future Workers

Anticipated Outcomes	Outcomes to Date	%
Implementation of I-STEM curriculum into the 26 elementary schools in the region without comprehensive, research-based science, technology, engineering and math curriculum.	• Since Tecumseh Area Partnership (TAP) became a WHIN grantee in 2018, 11 elementary schools have offered TAP's STEM programming to more than 913 elementary students.	42%
Implementation of Project Lead the Way (PLTW) into the 22 middle and high schools without research-based science, technology, engineering and math curriculum.	• Since Tecumseh Area Partnership (TAP) became a WHIN grantee in 2018, six middle schools have offered TAP's STEM programming to more than 1,336 middle school students.	27%
3,000 high school enrollments in STEM career education courses region-wide (from the baseline of 1,558 current high school enrollments).	• Since Tecumseh Area Partnership (TAP) became a WHIN grantee in 2018, 17 high schools have offered TAP's STEM programming to more than 947 high school students. Seeger High School currently has 295 high school students enrolled in STEM career education courses.	41%
750 "STEM-Ready" high school graduates (who have taken at least 1 STEM-related course).	• Seeger High School had 33 high school students graduate with Ivy Tech STEM dual-credit courses.	44%
800 manufacturing and agriculture industry-recognized credentials awarded in high school (from the baseline of 420 current credentials awarded).	• Two grants (Eleven Fifty Academy and Indiana West Advantage/Ivy Tech Precision Ag) awarded through WHIN's Regional Cultivation Fund in 2020 expect to yield these credentials in years 4 and 5.	0%

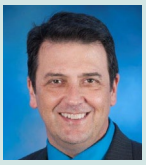
AIM 3.5: Cultivation Fund

Anticipated Outcomes	Outcomes to Date	%
The population grows and the tax base is strengthened. This will be measured by a baseline assessment of population and current tax base in all ten counties, tracked annually.	• Population and gross assessed property value on a county level are tracked by PCRD via the Rural Indiana Stats portal (http://pcrd.purdue.edu/ruralindianastats) and updated annually. According to the 2019 report, the aggregated gross assessed property value for the Wabash Heartland Region was $935,643. American Community Survey (ACS) has a five-year rolling sample that provides the updates for our remaining CVIs. According to 2018 data, the aggregated county population increase for the Wabash Heartland Region was 2,546 people (a slight increase overall in the WHIN region even though every county but Tippecanoe is declining).	100% of target (50% of goal over 5 years)
Within two-four years, WHIN will fund $10 million in projects in the WHIN counties designed to increase the region's vitality, education, and connectivity.	• Continue to work with Round 1 and Round 2 grantees. The Wabash River Enhancement Corridor (WREC) was awarded a $1 million grant to continue to plan a WHIN regional trail system.	30% (just over $3 million granted)
In five years, WHIN will have a positive impact upon educational opportunities, vitality, and connectivity of the Wabash Heartland Region as a result of the funded projects.	• WHIN Administration is currently developing e-learning and entrepreneurship initiatives. WHIN hosted a series of virtual meetings with school superintendents (13 public schools and one private school participated) and MatchBOX.	To be tabulated at end of Year 5
Pre-survey delivered by Purdue Center for Regional Development to all ten counties in the region. Surveys completed by regional residents at county fairs, via social media, and with the local deployment/promotion assistance of LEDOs, Community Foundations, Extension, Chambers of Commerce, and other community partners.	• A needs assessment survey was deployed in August; currently 180 regional residents have responded. This baseline data will be used to inform WHIN's e-learning and entrepreneurship initiatives (mentioned above).	100% of target (50% of goal over 5 years)

WHIN Global Metrics **Note:** It is not appropriate to assign a "percent complete" to WHIN's Global Metrics since they are intended to track WHIN's economic progress over the five-year period and beyond.	
An annual growth rate of 3.13% in GRP over 5 years. • For every $1 of Lilly Endowment, Inc. investment, the Wabash Heartland region would generate approximately $3.24. (e.g. $126M).	• PCRD has estimated the annual growth rate of GRP from 2016 to 2019. The average annual (year-by-year) growth rate of real GRP from 2016 to 2019 is 1.4%. The annual compound growth rate of real GRP from 2016 to 2019 is 1.21%.[1] Note that economic databases have revised the historical GRP data and different models give different estimates for 2019. The official estimates from the Bureau of Economic Analysis (BEA) are not yet published. The real GRP in 2016 (based on $2019) was $16.23 billion, which was estimated as $16.83 billion in 2019.[2] • From September 2019 through August 2020, WHIN's tech partners attributed $715,000 in sales revenue directly to their involvement with WHIN. None of the agriculture businesses nor manufacturing companies that WHIN has been partnering with reported any increase in sales revenue as a result of their involvement with WHIN.
2% job growth in next-generation manufacturing over 5 years and 3% job growth in digital agriculture over 5 years, resulting in 652 new jobs in the region over the same time span of the grant period.	• We use the most conservative category of only covered-workers under the Unemployment Insurance (UI) Program available from the Bureau of Labor Statistics (BLS) data and compare 2019 jobs against the 2016 BLS baseline. We have determined that a 6% (6.2% precisely) job growth has occurred in the Wabash Heartland's next-generation manufacturing industry (defined as the 58 industry sectors of the metal processing supercluster). Similarly, 10% (9.6% precisely) job growth has also occurred in the digital agriculture industry (defined as the 93 industry sectors of the ag-biosciences supercluster). • PCRD compared 2016 baseline data to the current 2019 employment data to find that at least 1,171 jobs have been added in the ag-biosciences supercluster in that timeframe, and almost 1,226 jobs had been added in the metal processing supercluster in that timeframe for a total of 2,397 jobs gained in these industries since 2016.[3,4,5]
125 positions will be filled in critical-need areas over 5 years (such as data analytics, precision agriculture, and IoT-related manufacturing).	• Further analysis needs to be done to conclude what percentage of these 2,397 jobs were "critical needs" positions and what percentage of these occurred in companies directly affiliated with/impacted by WHIN. • According to the 15 tech partners, ag businesses and manufacturing companies interviewed for WHIN's mid-point economic impact analysis, a total of 23 critical-needs jobs have been created by WHIN's tech partners (Solinftec, Guardian, and Intelinair) and academic partner (Ivy Tech).

1. Annual compound growth rate of real GRP (Gross Regional Product) should be used.
2. The numbers in the report are based on the EMSI model.
3. The BLS data for job changes within the metal processing supercluster is being led by a few specific industry sectors, which include automobile manufacturing, travel trailer and camper manufacturing, and other motor vehicle parts manufacturing. Between 2018 and 2019, overall the cluster had a job loss of 165 jobs.
4. The jobs change within the ag-biosciences supercluster is being led by a few specific industry sectors, which include meat processed from carcasses, pesticides and other agricultural chemical manufacturing, animal slaughtering, animal production, wet corn milling, Research and Development in Biotechnology (except Nanobiotechnology) in 11th rank, etc. Between 2018 and 2019, overall the cluster added 334 jobs.
5. The cluster definitions include a variety of industry sectors and emanate from the original BATTELLE's study, PCRD's research during grant application, and feedback from the WHIN team.

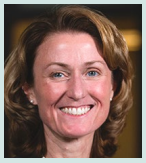
APPENDIX C: **Biographies**

WHIN Board (MEETS BIMONTHLY)		
	**Gary Henriott**	Chair of Henriott Group (insurance and risk management services) and past Chair of Greater Lafayette Commerce Economic and Community Development Council; City of Lafayette Housing Authority; President of Board of Works and Safety – City of Lafayette, IN; Lafayette Community Bank Board; The Community Foundation of Greater Lafayette Board, and Chair of Community Commitment to Education Committee.
	**David Bathe, DA**	Chancellor of Ivy Tech overseeing Lafayette, Logansport, Crawfordsville, Frankfort, and Monticello campuses. Leadership roles include Greater Lafayette Commerce, the Greater Lafayette Convention and Visitors Bureau, and the City of Lafayette Economic Development Commission.
	**Ron Dickerson**	Retired Vice President / General Manager – Nucor Steel Indiana and has most recently served as President of the Montgomery Economic Development organization; Community Foundation of Montgomery County.
	**David Lasater, PhD**	President and CEO of The Community Foundation of Greater Lafayette, Indiana. Previously served in a variety of capacities for 17 years with Purdue University and the Purdue Research Foundation, most recently as Senior Associate Vice President.
	**Gary Lehman**	Purdue University Board of Trustees, retired Chairman of the Board of Oerlikon Fairfield and President of Oerlikon AG-Americas, and the founder of Cannelton Group. Gary's leadership roles include Board of the Indiana Chamber of Commerce, Indiana Manufacturers Association, North Central Health Services, Ivy Tech Corporate College, and Greater Lafayette Commerce, Chair.
	**Stephanie Long**	President/CEO of North Central Health Services (NCHS), River Bend Hospital – a private inpatient psychiatric hospital, and capital grantmaker to eight of the 10 counties in the WHIN region. Previously served as CEO at IU Health White Memorial Hospital. Community leadership roles include White County Economic Development Board of Directors; Greater Lafayette Commerce Board of Directors; and Community Foundation of Greater Lafayette.
	**David Luhman**	Of Counsel to the law firm of Hoffman, Luhman & Masson, PC in Lafayette, Indiana. Leadership roles include Tippecanoe County Attorney (1997-2014) and counsel for Wabash River Enhancement Corporation, Tippecanoe County Parks and Recreation Foundation, and The Community of Greater Lafayette Board of Directors, Chair (2013-2016).
	**Todd Miller**	President/CEO Myers Spring, Logansport, Indiana. Community leadership includes Indiana Chamber of Commerce, Cass County Logansport Economic Development Organization, Logansport Municipal Utilities.

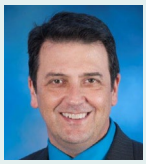
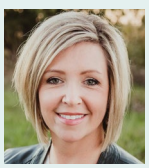
WHIN Board (Cont'd)

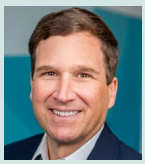
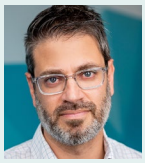
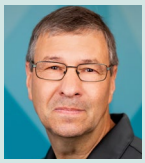
	**Johnny Park, PhD**	Chief Executive Officer (CEO).
	**Steve Schultz**	Chief Legal Officer for Purdue University. Previously with Barnes & Thornburg, Indianapolis; Fried, Frank, Harris, Shriver & Jacobsen, London, England; General Counsel with Irwin Financial, Columbus, Indiana; and Chief Counsel to former Indiana Governor Mitch Daniels.
	**Andrea Schwartz**	Dean, School of Advanced Manufacturing, Engineering & Applied Science and Associate Professor of Agriculture, Ivy Tech. Community leadership roles include Greater Lafayette Commerce Workforce 2030 and Agribusiness Council of Indiana.

Purdue Leadership (MEETS QUARTERLY)

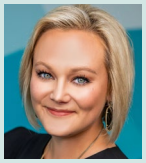
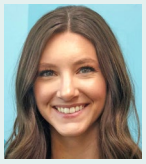
	**Jay T. Akridge, PhD**	Provost and Executive Vice President for Academic Affairs and Diversity. He also served as Principal Investigator for the WHIN-Purdue.
	**Theresa S. Mayer, PhD**	Executive Vice President for Research and Partnerships. She is also a Professor of Electrical and Computer Engineering.

Ivy Tech Leadership (MEETS QUARTERLY)

	**David Bathe, DA**	Chancellor of Ivy Tech overseeing Lafayette, Logansport, Crawfordsville, Frankfort, and Monticello campuses. Leadership roles include Greater Lafayette Commerce, the Greater Lafayette Convention & Visitors Bureau, and the City of Lafayette Economic Development Commission.
	**Todd Roswarski, PhD**	Ivy Tech-Lafayette Vice Chancellor for Academic Affairs & Professor of Psychological Sciences. Roswarski oversees all academic programs, grants, secondary initiatives, library services, and testing and assessment. He also serves on the Campus Academic Officers' Committee that sets all academic policy for the Statewide Community College System. Dr. Roswarski serves as Principal Investigator for WHIN-Ivy Tech.
	**Andrea Schwartz**	Dean, School of Advanced Manufacturing, Engineering & Applied Science and Associate Professor of Agriculture, Ivy Tech. Community leadership roles include Greater Lafayette Commerce Workforce 2030 and Agribusiness Council of Indiana.

WHIN Staff (MEETS WEEKLY)		
	**Johnny Park, PhD**	Chief Executive Officer (CEO).
	**Jack Stucky**	Vice President of Engineering.
	**Jason Tennenhouse**	Vice President of Strategy & Design.
	**Greg Ottinger**	Vice President of Strategic Partnerships.
	**Pat Corey**	Vice President of Engagement
	**Ted Fiock**	WHIN-Purdue Managing Director.
	**Chad Martin**	WHIN-Ivy Tech Project Manager.
	**Zach Mason**	Senior Software Engineer.
	**Audette Taylor**	Director of Finance.

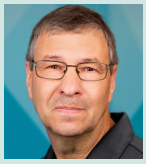
WHIN Staff (Cont'd)

	**Jessica Strasburger**	Regional Engagement Manager.
	**Alivia Roberts**	Marketing and Communications Manager.
	**Josh Karshen**	Member Success Manager.

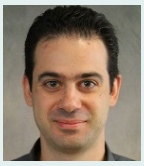
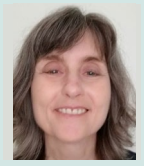
WHIN-Purdue Operations Team (MEETS MONTHLY)

	**Ali Shakouri, PhD**	Mary Jo and Robert L. Kirk Director of Birck Nanotechnology Center; Professor of Electrical and Computer Engineering.
	**Jan-Anders Mansson, PhD**	Distinguished Professor of Materials & Chemical Engineering; Director of Purdue's Composite Manufacturing Simulation Center (CMSC) and Co-Director of IN-Mac. Dr. Mansson is also the founder of the composites companies EELCEE Ltd. and QEESTAR Co. Ltd., which are active in the field of high-volume composites and additive manufacturing.
	**Dennis Buckmaster**	Professor of Agricultural & Biological Engineering, Dean's Fellow for Digital Agriculture.
	**Roberto Gallardo, PhD**	Director of the Purdue Center for Regional Development and Director of the Extension Community Development Program.
	**Steven Dunlop**	Managing Director of Dauch Center for the Management of Manufacturing Enterprises (DCMME) and Global Supply Chain Management Initiative (GSCMI).

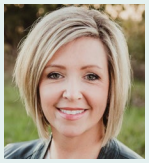
WHIN-Purdue Operations Team (Cont'd)

	**Melinda Grismer**	Community and Regional Development Specialist, Purdue Center for Regional Development.
	**Nathan W. Hartman, EdD**	Head of Computer Graphics Technology, Dauch Family Endowed Professor, and Co-executive Director of IN-MaC.
	**Ted Fiock**	WHIN-Purdue Managing Director.
	**Jason R. Henderson**	College of Agriculture Administration, Associate Dean and Director of Purdue Extension.
	**Ananth Iyer, PhD**	Senior Associate Dean, Krannert School of Management; Susan Bulkeley Butler Chair in Operations Management.
	**Michael Ursem**	Director of Business Development & Facilities, IN-MaC.
	**David Snow**	Center Director, Manufacturing Extension Partnership.
	**John Sutherland, PhD**	Professor and Fehsenfeld Family Head of Environmental and Ecological Engineering.
	**Nithin Raghunathan**	Research Scientist, Birck Nanotechnology Center.

WHIN-Purdue Operations Team (Cont'd)

	**Martin Jun**	Associate Professor of Mechanical Engineering.
	**John Scott**	Digital Agriculture Extension Coordinator.
	**Bruce Erickson**	Digital Agriculture Education & Outreach Director.
	**Maria Wiltse**	Metrics Manager, Purdue Center for Regional Development (PCRD).
	**Charilaos Mousoulis**	Project Manager of IoT Infrastructure and Data Analytics, Senior Research Scientist, School of Electrical and Computer Engineering.
	**Somali Chaterji**	Assistant Professor of Agricultural and Biological Engineering.
	**Andrew Balmos**	Data/Software Engineer in Agricultural Research and Graduate Education.
	**Nancy Denton**	Professor & School of Engineering Technology Associate Head.

WHIN-Ivy Tech Operations Team (MEETS MONTHLY)

	**Andrea Schwartz**	Dean, School of Advanced Manufacturing, Engineering & Applied Science, Ivy Tech.
	**Chad Martin**	WHIN-Ivy Tech Project Manager.
	**Bryce Eaton**	Program Chair, Advanced Automation & Robotics Technology.
	**Kraig Bowers**	Program Chair, Agriculture.
	**Andrew Gibbs**	Department Chair, School of Computing & Informatics.
	**Bruce Sillery**	Farm Manager and Crop Production Faculty.
	**Todd Roswarski, PhD**	Vice Chancellor of Academic Affairs.

Frequently Used Acronyms

ABE.....Purdue School of Agricultural and Biological Engineering

ACIS.....Applied Climate Information System

ACRE.....Purdue College of Agriculture's Agronomy Center for Research and Education (a testbed site)

CBRS.....Citizens Broadband Radio Service

CRM.....Customer Relationship Management

DCMME.....Dauch Center for the Management of Manufacturing Enterprises

DSCT.....Digital Supply Chain Tool

EDA.....Economic Development Administration

GCTC.....Global Cities Team Challenge

IMI.....Indiana Manufacturing Institute (located at Purdue Research Park)

IMT.....Intelligent Manufacturing Testbeds

IN-MaC.....Indiana Manufacturing Competitiveness Center (located at Indiana Manufacturing Institute)

IoT.....Internet of Things

ISP.....Internet Service Provider

IWA.....Indiana West Advantage

LEDO.....Local Economic Development Organization

MEP.....Manufacturing Extension Partnership

MET.....Manufacturing Education Team

MPATI.....Midwest Program on Airborne Television Instruction

NIST.....National Institute of Standards and Technology (a federal government organization)

NCHS.....North Central Health Services

NOAA.....National Oceanic and Atmospheric Administration

NSF.....National Science Foundation

OATS.....Open-Agriculture Technology and Systems Group (a Purdue Ag and Engineering research team)

OED.....Office of Energy Development

OEM.....Original Equipment Manufacturer

ONA.....Occupational Skills Needs Assessment (a survey to be conducted to assist with metrics)

OTC.....Office of Technology & Commercialization

PAET.....Precision Agriculture Equipment Technology

PCRD.....Purdue Center for Regional Development

PPE.....Personal Protective Equipment

RCF.....Regional Cultivational Fund

RFP.....Request for Proposal

RTO.....Rural Technology Operators

RWIN.....Rural Workforce Innovation Network (a USDA public-private partnership)

SBIR.....Small Business Innovation Research

SCT.....Supply Chain Tool

SME.....Small-Medium Enterprises

TOWER.....Testbed for Open Wireless Experimental Research

TPAC.....Throckmorton-Purdue Agricultural Center

UAV.....Unmanned Aerial Vehicle

VR.....Virtual Reality

VSMI.....Value-Stream Mapping—Infection

WHIN.....Wabash Heartland Innovation Network

WREC.....Wabash River Enhancement Corporation