WHIN

WABASH HEARTLAND
INNOVATION NETWORK

Report to Lilly Endowment

March 2021

Submitted by: Johnny Park, CEO, WHIN

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Message from the Chairman:

The Road Ahead

As I write this message, the sun is shining on this unusually warm and bright late-winter day. Spring is coming: new growth is sprouting and the new hope that only can be found at this time of the year is returning. I feel this same sense of anticipation, new growth, and positivity in the Wabash Heartland Innovation Network. It seems that each day brings new ideas, new relationships, and new opportunities for collaboration and synergy. As we move into the last 18 months of our grant period, the efforts of the WHIN team coupled with the incredible support of our stakeholders are moving us closer to the realization of our vision of transforming the Wabash Heartland Region into a Living Laboratory where "globally competitive businesses can plant and grow." Our Living Laboratory is an ecosystem giving rise to an "epicenter of digital agriculture and next generation manufacturing." All of this is being undertaken with our ultimate objective of this work in mind—increasing opportunity and prosperity for the people who call this place home.

The next six months are critical to the future of WHIN. Our organization has embarked on the creation of WHIN 2.0, our strategic plan for the next three to five years. A central focus of this plan is how we envision the Living Lab of the future. How will the creation of this unique asset enliven our community life and engagement? How will this unique asset accelerate the adoption of current and emerging technology within the region? How will this unique asset foster research and the development of new technologies and discovery? How will data generated in the Living Lab lead to new AI development and data analytic insights? How will the development and creation of this unique asset allow affordable and accessible broadband services to our residents, our businesses, and our students? How will this unique Living Lab attract both talent and capital investment in our region? These are the questions that WHIN 2.0 must address, and the way those questions are answered will significantly impact us in ways that we cannot begin to imagine.

This is our time to illustrate clearly to our stakeholders and our community the almost limitless value of what WHIN is creating. It is incumbent upon us to demonstrate how our region will be

transformed by our efforts and also to provide a model of how our work can be translated to help others in Indiana and beyond.

The recently published GPS report from the Brookings Institute, funded by Lilly Endowment, clearly states the challenges we in Indiana face. The concerns raised and opportunities that were outlined in the report are aligned with the goals that WHIN was created to accomplish the development of a globally competitive economy that accelerates the adoption of new technology, advances research and development, creates a vibrant educational learning environment for students of all ages, and builds community. WHIN is already at work on much of what the report recommended.

The tasks ahead of us can at times seem to be daunting. But we have incredible resources and talent on our side. The WHIN team that CEO Johnny Park has assembled, is single-mindedly focused on accomplishing and exceeding our goals and objectives and meeting the various challenges that we encounter. We are exploring new and creative ways to align so that WHIN's efforts will advance, enable and enrich their missions as they utilize our Living Lab and the ecosystem it is creating. At the same time, we are engaged with our partners, Purdue and Ivy Tech, and they with us. Purdue and Ivy Tech are vital to this ecosystem's development, implementation, and ultimate success. And, we are thankful for the support, guidance, and faith that Lilly Endowment has exhibited in our organization since our creation. You have provided us with this unique opportunity to impact those who live and work in our region and we accept this responsibility with much gratitude.

Thanks to all who have, are, and will help make this vision a reality in the months and years ahead!

Gary D. Henriott, Chairman

WHIN Overview: **Foundations to Build On**

We often feel as though WHIN is a ship that is being built even as it is being sailed. And in many ways we are.

There is not even a blueprint for what we are doing, at least insofar as developing the WHIN organization goes.

What we now call WHIN 1.0 gave us a lot of DNA: innovation, research, education, IoT, regionalism. It also gave us a purpose: *to cultivate a prosperous regional ecosystem that empowers globally competitive businesses to plant and grow in the Wabash Heartland*. And it gave us partners in Purdue University and Ivy Tech.

But the solid black line between IoT research/education and regional transformation within a five-year grant period not only had yet to be drawn, much less realized, it would have to be drawn and realized by a community-based 501c3 organization. No one had done anything like that before.

WHIN's Living Lab model has been the result: an ecosystem in which the region benefits from the real impact of new, innovative IoT-in-use while supporting IoT research and education.

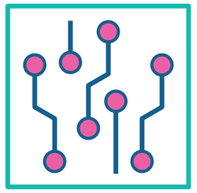
The Living Lab is having the desired results. But WHIN's commitment to advancing its region through accelerated adoption of digital technology has had to rely entirely on proof of concept: try it and see if it works. Build the ship while it is sailing.

That is until two reports were released that provided data-driven support for WHIN's approach.

The first report, "A Case for Rural Broadband," was published by the USDA in 2019. In making the case for rural broadband, the USDA also made the case for digital agriculture, which is to say for IoT-in-use by the ag sector including producers. According to that report, realizing the full potential of digital technology in agriculture would result in economic benefits equivalent to nearly 18% of total production.

That is a very solid black line between adoption of technology and economic benefits. The problem is that it doesn't quite reach the WHIN goal of empowering globally competitive businesses to plant and grow. Agriculture is product-rich, not jobs rich. But it was a start toward justifying WHIN's strategy.

The breakthrough came with the Indiana GPS report released in 2021 by the Brookings Institute. Commissioned by CICP with LEI funding, the report is a deep dive into Indiana's record and prospects for creating more good jobs for Hoosiers.



Among many Brookings recommendations, the very first was to increase digitalization in the state's advanced industry sector, which includes both advanced manufacturing and advanced services.

Brookings' inclusion of digitalization, which is the adoption of digital technology, much less its position at the top of the class, is startling, prescient, and incredibly logical.

As the report notes, digitalization is overwhelmingly linked to productivity. And productivity is linked to good jobs in advanced sectors.

WHIN Board retreat, planning for WHIN 2.0.

WHIN Overview: **Foundations to Build On** *(Cont'd)*

Maiden flight of WHIN's aerostat.

Perhaps one reason digitalization has not received the attention it deserves is that it cuts very close to how work is done: it affects operations. It is easier to see a role for the public and social sectors in attracting jobs around the edges. Thus, direct investment focus has been limited to tax abatements or investment to encourage plant construction, training, and workforce development, while also investing in context: quality of life amenities to attract young, skilled talent.

But it is at the operational level that jobs accrue value, require skill, and affect productivity.

It is no wonder then, that WHIN's model, which goes right to the heart of digitalization and accelerates adoption of technology in real operations with 501c3 dollars, has had some explaining to do about why that strategy should and will work.

And thanks to GPS, that explaining just became much, much easier. WHIN is accelerating GPS's number one recommendation in the Wabash Heartland and there is now a solid black line between that core strategy and WHIN's True North. Boost productivity and jobs will follow.

Notably, WHIN's model goes even further, including a strong job attraction component based on the tech sector behind digitalization, whether that be sensors, telecommunications, or applications. Its Living Lab model gives tech companies a strong reason to be in the region. Their jobs are and will continue to arrive in the region even faster than those due to productivity gain.

Furthermore, tech companies are part of the advanced service sector, and to the extent that they serve the ag sector, they make Indiana's vital ag industry a key player in good job attraction. This is a very new and high-profile role for agriculture to work in tandem with advanced manufacturing in Indiana to create opportunities for Hoosiers.

As well, the Living Lab is a fertile field for startups to plant and grow, attracting VC and private equity investment: another key GPS recommendation.

WHIN's track record during the LEI grant with digitalization offers the state a pilot run of key GPS recommendations. WHIN's scalability adds even more value. We are so grateful for GPS. We are thrilled to see the state rally around the themes that have driven WHIN so far and that are the foundation for WHIN 2.0 which will take WHIN and the Wabash Heartland into the next five years and beyond.

Of course, we continue to complete grant provisions that support the entire digital technology value chain. Purdue's research activities and their engagement with the region are pushing digitalization forward into next generation technology. Both Purdue and Ivy Tech are creating the workforce the digital world needs. For WHIN's True North to be reached, all of those cylinders need to be firing.

We also continue to help the region through RCF quality-of-life investments that touch lives while boosting the region's attractiveness to talent and business. E-learning is addressed in this report along with progress on WHIN's rural broadband strategy overall.

Finally, as the pandemic eases and federal dollars arrive, we are heartened to be a recognized regional leader in regional solutions to such high priority areas as broadband. As we look forward, that leadership will become more and more critical as our region helps set the course for the state.

Johnny Park, WHIN CEO

Digitalization: **The Human Factor**

WHIN is people helping people

As the GPS report notes, there is a link between investment in technology and productivity. That is a statistical calculation that is driven by what people do when they work, including the tools they have that enable them to do their jobs more efficiently and better.

That is, then, where change matters.

How does an organization like WHIN help growers and the small-to-medium manufacturers that are the majority of the region's industry become willing to adopt technology that enables people to work more productively, individually and collectively?

WHIN's approach is to meet them where they are. Recognizing that its 2018 pivot to digitalization would mean developing trusting relationships with individual farmers and manufacturers, WHIN engaged someone with hands-on experience in both sectors.

Greg Ottinger (left) is WHIN's Vice President of Strategic Partnerships. After earning an engineering degree from Rose-Hulman and two MBAs from IU, Greg spent 34 years in manufacturing, achieving executive levels of management. Along the way, he worked with Lean Manufacturing, Six Sigma, Toyota Production Systems, DOT, and FDA regulatory and quality control manufacturing requirements. Greg is also a lifelong farmer who continues to manage his family's farm.

Above all else, Greg does not identify as a salesperson, a role that he never envisioned for himself, as he points out regularly to the WHIN team! He approaches his job of recruiting WHIN Alliance members as a colleague and a peer, with great empathy for the pressures they feel and for their skepticism toward untried solutions, a skepticism Greg shares.

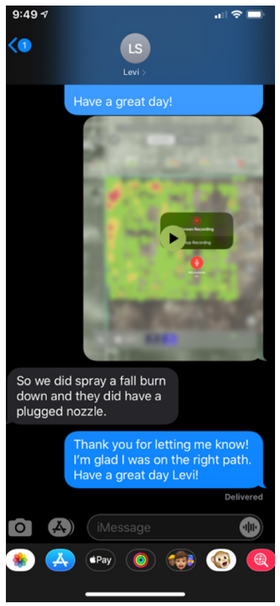
Greg brings those qualities not only to his one-on-one work with farmers and manufacturers but to his part in vetting the technology that he hopes they will consider adopting. Along with Vice President of Engineering Jack Stucky and CEO Johnny Park, Greg identifies commercial and near-commercial networked digital technology that will affordably return immediate value.

WHIN's vetting pays off for Alliance members, lowering a key barrier to adoption, namely the time and effort it takes to identify and assess not only a technology but the company itself.

A prospective WHIN tech partner must have a solid business plan, offer fast ROI to customers, and provide strong customer service. Indeed, WHIN assesses tech companies much the way a potential investor would.

This doesn't mean that the company must have a long track record with a product. In fact, WHIN's Living Lab is an ideal way to test a promising technology in real world conditions. Nor must the company itself be mature. WHIN has worked with startups like RogoAg, a robotic soil testing company that was developed by a team from Purdue. Given the experience of much of WHIN's technical team in startups themselves, they bring not only an experienced eye but sound advice.

Tech partners must be willing to take some of the risk in accelerating adoption, providing discounts to complement WHIN's own investment. Together, the tech company and WHIN substantially lower another major barrier to initial adoption: cost.



Ag Alliance tech partner Intelair's customer service model is highly engaged.

Finally, most new products must pass through a pilot period with a few growers or manufacturers before they are offered to the entire Alliance.

Once a technology is in wider use, the Alliance serves as a community of users helping each other learn to solve problems in a new way.

The result? An increasingly digitalized WHIN region.

Digitalization: **The Human Factor** *(Cont'd)*

solve problems with technology

A case in point is WHIN's newest prospective manufacturing tech partner, a young Iowa firm called MakuSafe. MakuSafe specializes in wearable IoT that is designed to improve worker health, safety, and productivity.

Employees are equipped with a pager that is inserted into an armband that they wear throughout their shift. The pager communicates with antennas mounted in the plant's ceiling.

As the employee works, the device's accelerometers pick up sudden changes in gait and position that indicate a trip, fall, dodge, or other unexpected motion. The incident is recorded along with the location.

MakuSafe charging station.

The plant's safety manager has access to the data and can note whether multiple incidents are occurring in the same location, indicating a hazard that needs to be removed.

The device also detects force and generates a report that may indicate an equipment failure or positioning problem that is causing an employee to have to push, pull, or lift dangerously. It detects carbon monoxide and decibel levels. Employees can also report hazards with their devices.

In other words, Makusafe technology allows safety managers to proactively monitor work environments both directly and indirectly, through how that environment is affecting workers. Hazards can be addressed much more quickly.

Standard Industrial President Bryce Brumm at the station where his team picks up MakuSafe devices when they report for work.

MakuSafe technology has also helped tracing during the COVID-19 pandemic, identifying employees who have been within four-six feet of someone who tested positive.

MakuSafe is currently being piloted for WHIN by Industrial Standard in Pulaski County. Standard Industrial manufactures components for vans adapted for wheelchair accessibility by another WHIN Alliance member, Braunability.

Braunability is the largest employer in Pulaski County and is now a global leader in mobility solutions.

The MakuSafe pilot at Standard Industrial is going so well that the product is likely to be made available very soon to all of WHIN's Manufacturing Alliance members.

MakuSafe installation and customer service.

The Power of the Living Lab:
Rethinking Technology-Based Infrastructure

Innovation

It's official! WHIN's Living Lab has deployed innovative technology around the I in IoT. On March 31, WHIN's RTO Wireless AeroSite™ aerostat had a successful test flight to an altitude of 1,380 ft. It joins our Alliance network of installed sensor-based technology to form a complete and innovative researchable IoT solution, advancing the WHIN region as the place to come for IoT innovation including broadband and LoRaWAN.

WHIN's aerostat is located in Reynolds, White County.

As with all of the commercial and near-commercial technology that WHIN introduces into the Living Lab, the aerostat was selected after a lengthy vetting process because it has the potential to serve IoT research by way of serving actual IoT needs, specifically, the need for connectivity.

Given the considerable funding being made available by the federal government to accelerate rural broadband, it is reasonable to ask, what difference can WHIN make?

WHIN's difference is not to add a drop to the ocean of funding that is fueling especially fiber buildout in sparsely populated rural areas. That buildout must continue apace but it is not WHIN's job to add a few more miles to what is termed broadband infrastructure.

To ask what difference WHIN can make is to ask, what difference does innovation make? Can it make a difference?

Fiber is the gold standard for broadband infrastructure. Many regard it as an innovation-proof, which is to say, future-proof, build-it-right-the-first-time, solution for rural broadband. That begs the question, if a federal investment could be made such that a one-gig pipe of fiber ran to every home and business in the U.S. in the next six months, building over what is already deployed at lesser standards, would we be done with the digital divide?

The answer is found in the one-gig pipe and the need it begets for rebuilding. For all of the virtues that make it the backbone of the internet, fiber is deployed with a fixed capacity, and there is no reason to think that the present standard is the final standard. Quite the opposite: bandwidth standards have risen exponentially to meet demand and no end is in sight. Notably, adding a lane or three to existing fiber infrastructure is tantamount to rebuilding it.

Urban broadband service providers have a business model based on high density that allows for fiber to be deployed and upgraded with less public investment.

Low density rural broadband does not have a business model to deploy fiber affordably the first time without substantial help from government grants. And, without repeated public investments in rural infrastructure, the digital divide will likely reemerge in a few years as it already is in areas that have fiber built to older standards.

This is not an argument against fiber infrastructure! It simply recognizes that even the most apparently future-proof broadband infrastructure must respond to the digital technology demand curve, which is the antithesis of future-proof. The expensive response is to rebuild. The less expensive response is to innovate in ways that avoid frequent, extensive rebuilds

What's in it for the WHIN Region?

- The chance to benefit directly from the innovative solutions like the aerostat that are being tested in the Living Lab.
- A higher profile regional broadband footprint, which can incentivize broadband service providers who win federal dollars to spend them earlier rather than later in the WHIN region.
- The Living Lab model attracts tech companies to work in the region. They bring good jobs. The broadband sector is very large.

The Power of the Living Lab:
Rethinking Technology-Based Infrastructure *(Cont'd)*

helps infrastructure keep pace

The Rural Digital Landscape is Diverse

In the focus on broadband, a very specific connectivity need for the uplink from sensor technology like this weather station, can get lost. Sensors in remote, low-power areas cannot be served by broadband, which drains batteries. Narrow-band LoRaWAN is the emerging standard for this need.

WHIN already has gear installed on the ground that will make it one of the largest contiguous LoRaWAN networks in the country. The aerostat will allow further testing of networks that co-locate the broad and narrow band technology that is critical to digital agriculture.

In fact, we could say that broadband innovation introduces the elasticity that helps expensive, fixed-capacity infrastructure respond incrementally to demand, extending its life by relaxing its rigidity. WHIN's Living Lab is a place for figuring out where and how to introduce elasticity into broadband infrastructure.

Sometimes that innovation involves fiber itself, as with WHIN's aerostat, which runs fiber vertically in free space. This enables a short stretch of fiber to provide backhaul that would require miles of fiber on the ground.

For that vertical fiber to be of use, it has to work with wireless technology. Wireless technology is a source of great stretchiness in a network, and it can be quickly deployed. Unfortunately, in its original incarnations in rural broadband, wireless technology, like baggy sweatpants, did not perform well.

Thanks to significant investment in wireless innovation by the federal government, rural broadband now has access to affordable, 5G-quality spectrum that is fixed-wireless-friendly and secure from interference. It also has access to affordable carrier-grade gear.

Notably, it is possible to have a business plan for wireless technology in low-density and hard-to-serve areas that is not possible for fiber. That is why the government remains interested in wireless even though the public, largely because of the historic problems with wireless, wants fiber.

And, notably, the federal government has been technology-agnostic, requiring mainly that its investments be used to meet a particular standard, within a particular timeframe.

This means that the pressure is on wireless to demonstrate that it can carry its weight.

With wireless technology in the mix, innovative network designs become feasible. There is also a stronger place for Cloud computing, AI, and machine learning enabling smart networks.

WHIN's Living Lab can serve all of those needs. And, in being Living, it can validate innovative solutions not only for their technical quality but also for their economic feasibility.

In its role outside of the industry, WHIN can also facilitate complex solutions at high levels like network design.

WHIN's aerostat operator concluded the flight.

Purdue-WHIN: Overview

Accelerating Technology Adoption and Workforce Education

More than 30 faculty, 25 staff, and 45 students from four Colleges at Purdue are part of the WHIN project, helping to accelerate the adoption of industry 4.0 and digital agriculture in our ten-county region.

As stated in the Indiana GPS Project, increased digital adoption is one of three key recommendations because it will "drive economic dynamism, productivity, and competitiveness." The report also recommended promoting favorable job creation and worker transitions to allow for a beneficial "rewiring" of the economy. WHIN is at the forefront of these efforts, by advancing both workforce education and technology adoption throughout the ten counties.

Purdue activities focus on:

Attracting National Centers of Excellence and Major Global Corporate Partnerships

Research collaborations have helped develop deep engagements with Bayer, Saab, Ericsson, Microsoft, Intel, Facebook, Fluke, and Hexagon—all high-tech companies attracted by our unique testbeds and by the broader efforts to create a living lab in the region. One example is the recently funded $26 million National Science Foundation Engineering Research Center IoT4Ag, in which Purdue is a key partner.

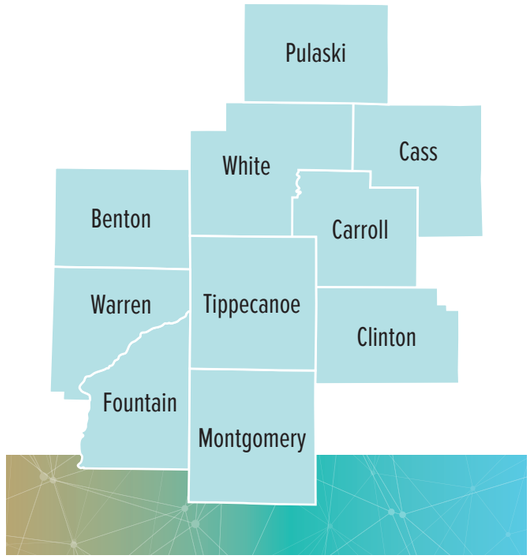
Building the Regional Ecosystem

In the last six months, we have engaged with 26 companies and farmers through sensor deployment and digital adoption projects. A total of 266 participants attended our webinars addressing topics ranging from technology adoption to workforce education. The Manufacturing Supply Chain tool was launched in September with over 150 company profiles. This tool describes each company's capabilities, products, and services information manufacturers and LEDOs can use to develop new, local, sourcing pathways. This tool has been accessed 1,153 times. Purdue Manufacturing Gateway, which has been established as a WHIN region pilot, provides a single point-of-contact for small and medium manufacturers to access and build collaborations with Purdue experts. In Agriculture, Purdue has engaged with 506 stakeholders through presentations, demonstrations, and other programs. We are also working closely with Ivy Tech to enhance their programs leveraging IoT sensors and data analytics developed at Purdue.

Sustaining Purdue-WHIN Efforts

So far, Purdue-WHIN has attracted new grants totaling $18.2M and is driving Purdue's internal investment of $19.8M. The additional resources will allow Purdue to continue some of the major WHIN activities after the LEI grant ends in August, 2022. This includes support of living lab testbeds through external grants of $4.3M and an additional Purdue investment of $2.5M to support staff hired under the Purdue-WHIN Project and for maintaining the testbeds.

Purdue is strengthening the ten-county region's capabilities as an Industry 4.0 leader. The regional collaborations developed between Purdue and regional manufacturers is now even stronger with three fully completed and dynamic testbeds. This creates partnerships unlike almost any other in the U.S., generating key interest from industry leaders—such as Saab's Chairman of the Board Marcus Wallenberg. Purdue is steadily leveraging this excitement and these strengths to create a stronger future for the entire WHIN region.



Purdue-WHIN: IoT Team

Diverse Expertise, Unified Goal

The Purdue-WHIN IoT team, based in Discovery Park's Birck Nanotechnology Center, brings together researchers in new sensors, electronics, networking, and data analytics who are working together with the common goal of making tomorrow's low-cost IoT technology and data analytics available for today's farmers and manufacturers.

Purdue-WHIN IoT Team Hosts Evonik Engineering Group

Purdue-WHIN's IoT group hosted a group of Evonik engineers to a class titled, "Predictive Maintenance through Sensor Technology." In early 2020, Evonik asked the Purdue-WHIN IoT group a question: "What does state-of-the-art maintenance sensor technology look like today and in the future?"

Purdue-WHIN IoT group present state-of-the-art maintenance technology with Evonik engineers.

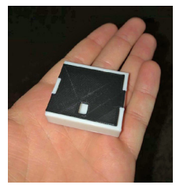
In late 2020, after a series of COVID-19 delays, the Purdue-WHIN IoT group came together to answer those questions for Evonik engineers. The IoT team discussed sensors commercially available today, and then presented what is being developed as the future of low-cost sensors and could be commercially be available in the future. Following the class, one of the Evonik engineers said, "The preventative and predictive maintenance applications presented today were very interesting to me. I can see several applications where we could use in our production facility and I would be interested how we might be able to collaborate further in the future." Since hosting the event, the IoT and Evonik teams have worked together to deploy several of the Purdue's low-cost sensor technologies at Evonik's Tippecanoe operations.

Purdue-WHIN plans to broaden the scope and tailor the workshop contents for other manufacturers in the region who seek to deploy diverse commercial and specialized wired and wireless sensors. This will benefit from a user-friendly and open-access data visualization, notification, and analytic platform developed by the IoT group. Data from different vendors can be combined and analyzed.

Proximity Detection in the Age of Pandemics

On many manufacturing floors, it is challenging to constantly monitor workers to maintain a safe distance from one another due to COVID. WHIN manufacturers were seeking an automatic, unobtrusive mechanism to keep track of safe distance practices and provide some alert before potentially dangerous situations might arise.

Purdue-WHIN has developed a solution that was so effective it appeared at the top conference in the topical area, Association of Computing Machinery's (ACM) Conference on Embedded Networked Sensor Systems. The Purdue-WHIN solution is unique for three reasons. It enables manufacturers to: (1) keep complete control of the data; (2) decide how much to pay and at what scale they want to deploy the solution; and (3) customize the solution, i.e. making the data available for uses such as tracking regulatory compliance or limiting data availability so it does not leave the device—protecting the privacy of the individuals.



Purdue-WHIN designed a proximity detection monitor small enough to be worn with a lanyard strap.

Furthermore, if surfaces need monitoring for touch, the transceiver can keep track of when a user last interacted with the surface. If a different user comes close to the surface, then a proactive alarm will be presented. This is important for manufacturing assembly line type operations.

The solution has been proven to work in typical manufacturing settings at Purdue, such as Birck and at the Indiana Manufacturing Institute (IMI). But the proof is real-world manufacturing applications with local WHIN manufacturers, which is being tested presently. It is in these scenarios, we are examining: (1) What is the detection rate? (2) What is the false positive rate? and (3) How long does the battery last? With these answers, Purdue-WHIN can possibly provide a long-term, valuable solution to manufacturers that can be customized to meet their needs.

Purdue-WHIN Teams Hold Year Three Update Conferences Updating the Region on our Progress

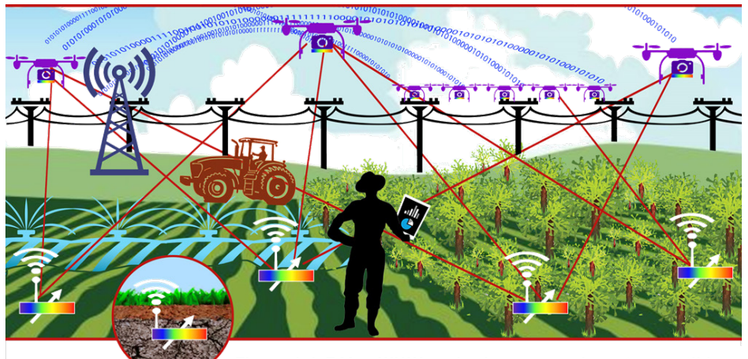
On Dec. 4th and 18th, the Ag and Manufacturing teams hosted virtual Purdue-WHIN Conferences with 92 attendees in total. Updates on WHIN-supported projects were presented and attendees were able to ask questions and brainstorm. The video presentations are available on the **Purdue Ag-WHIN Updates playlist** and on the website **Purdue-WHIN**.

Transforming the WHIN Region into a Digital Agricultural Epicenter

Purdue-WHIN continues their efforts to transform the WHIN region into a global epicenter for digital agriculture. Whether in the classroom, at our research labs or farms, or in the field with a local farmer, the Purdue-Ag team remains as the driving force moving Indiana agriculture forward into the digital age.

Engineering Research Center Work Begins, Greatly Leveraging WHIN Resources

With a five-year, $26 million grant, the NSF has established the Engineering Research Center for the Internet of Things (IoT) for Precision Agriculture (IoT4Ag). Engineering Research Centers (ERCs) are NSF's flagship engineering program for convergent research to address large-scale societal challenges.



Through IoT4Ag, WHIN and other research projects will have the funds and leverage to improve/increase some facilities, equipment, and personnel related to advanced agricultural technologies.

IoT4Ag is a significant infusion to tighten the collaborations between applications engineering, agronomy, robotics, and communication systems engineering at Purdue and beyond. The collaborations with other institutions should increase the quality of the work by leveraging expertise from assorted institutions as well as more academic disciplines.

The IoT4Ag funds also greatly leverage WHIN and other research project funds to improve/increase some facilities, equipment, and personnel related to advanced agricultural technologies within our testbed operations as well as education and training of graduate students. The inclusion of Purdue on this project is evidence of the leadership of Purdue faculty in this realm.

Just in the process of developing the projects data management plan, we have expanded understanding of data types and applications. One of the early projects is specifically targeting data architecture to facilitate the utilization of layers of data (soil, topography, imagery, machine data, sensor data, etc.). This is one of the realms where data in agriculture has not "delivered on the promise" because of the lack of interoperability. The collaboration across institutions includes direct ties to farms and agribusinesses typical of our region.

Another effort within the larger project is to integrate biophysical (simulation) models with data sets and streams. This holds potential to improve the value of data from sensors as well as contribute to the optimization of sensor deployments.

The Purdue-WHIN-Ag Team Hosts Fall and Spring Weekly Webinar Series

The Purdue team launched a 10-week series of digital agriculture webinars—**Digging into the Data Pipeline**—on October 1. From practical tips that can be implemented today to deeper dives into what drives the technology, the webinars feature data science and digital agriculture experts from Purdue-WHIN and throughout Purdue. In the first six weeks, between 10 and 30 individuals, including industry representatives from within the WHIN region and beyond, have joined each webinar and almost 90 people have registered for the series. Each webinar consisted of a pre-recorded presentation followed by a live Q & A session. All pre-recorded presentations were posted in a **playlist on Purdue Agriculture's YouTube channel**, and were promoted through emails and social media after the webinar, and had 2,164 views collectively.

Fueled by the successful Fall 2020 webinar series, Purdue-WHIN has recently enhanced and expanded the series for the Spring of 2021. The spring webinar series—"Data-Driven Agriculture: Today's Possibilities, Tomorrow's Potential"—has been promoted widely and includes several projects that have WHIN support. This semester's series includes presenters from across Purdue's College of Agriculture, as well as some of their industry partners.

More than 100 people are registered for the series, which takes place each Thursday at 12:30 p.m. ET through May 13. A complete list of the topics can be found at **https://ag.purdue.edu/digital-ag-resources/spring-webinar-series/**. Topics have included:

1) Data in Produce Safety;
2) Putting a Price on Data;
3) Smarter Treatment of Livestock Disease;
4) IoT Networks–Sensors and Data Visualization; and
5) Public Data for the Public Good.

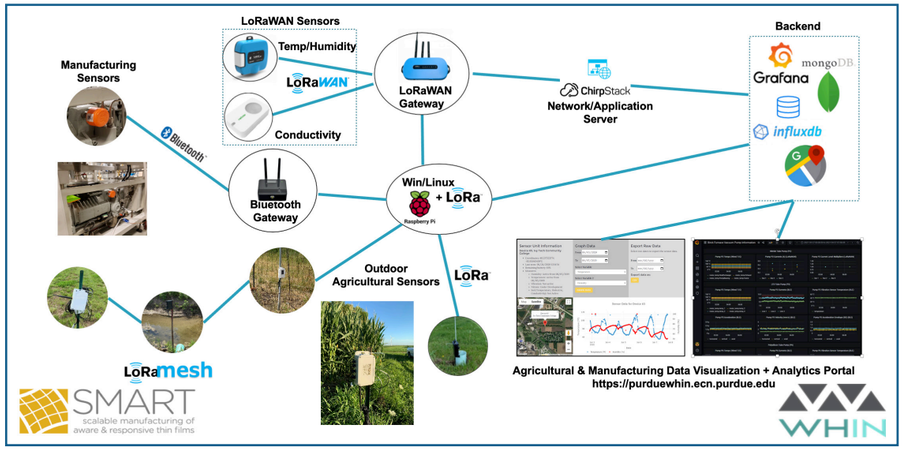
Purdue Ag Hosts Annual Crops Field Day

On September 3, the annual Crops Field Day, usually held at Purdue University's Agronomy Center for Research and Education, went virtual. As part of a larger program, Purdue Extension Coordinator for Digital Agriculture John Scott presented on 2020 UAV Insights. He walked the attendees through the process of how to go about scouting a soybean field using an Unmanned Aerial Vehicle (UVA). Purdue-WHIN Digital Agriculture team members Dennis Buckmaster and Bruce Erickson also gave brief updates on Purdue-WHIN efforts. Prof. Buckmaster gave an update on Purdue's ag IoT testbeds, which allow researchers to experiment with different ways to move the information from sensors to the cloud and to test different sensors and different architectures to store the data. Erickson gave an update on Purdue's efforts around delivering digital agriculture/data science curriculum at all levels—high school, undergraduate, graduate, and professional. Event organizers estimate about 85 individuals participated in the 2.5-hour field day event.

Purdue Extension Develops Digital Ag Curriculum for High Schools and Junior College Students

Building the regional ecosystem for digital agriculture will require a pipeline of digitally prepared next generation farmers and skilled workforce. To enhance this development, Purdue Extension has been developing a digital Ag curriculum for local high schools and community/junior college level students. As the curriculum becomes finalized, Purdue will enter into negotiations with Indiana high schools for adoption and implementation. We currently have one pilot with the Heartland Career Center in Wabash, Indiana and hope to expand into multiple WHIN region high schools.

Students participating in Purdue Extension's digital agriculture curriculum, currently being piloted at the Heartland Career Center in Wabash, Indiana.



A researcher gives an online presentation during the 10-week webinar series dedicated to promoting digital agriculture.

Accelerating Indiana's Role as a Digital Manufacturing Leader

Purdue-WHIN is working on multiple fronts to accelerate Indiana manufacturing's leadership as a digital ecosystem. Activities focused on expanding the IMI testbed, continue working with local manufacturers, as well as expanding the workforce training program.

IN-MaC, Purdue-WHIN Partners with Regional Manufacturers in Augmented Reality Study

Augmented reality is being used to develop training modules for onboarding new employees or refreshing current employees in the region.

As the digital transformation of manufacturing continues to evolve, companies are looking at additional ways to leverage technology to improve their operations within the workforce training space, and one of those technologies is Augmented Reality (AR). AR is the use of hardware and software to create graphical representations of objects or processes that can be superimposed on the user's view of the world. If you have seen Microsoft's Hololens or Google's Cardboard technologies, then you have seen AR. Through a collaboration with Purdue-WHIN, the Indiana Manufacturing Competitiveness Center (IN-MaC) is partnering with Tate & Lyle and Evonik to develop training modules for onboarding new employees or refreshing current employees. The training will focus on factory processes that are common to most companies, regardless of their industry sector.

The team has selected safety Lock Out/Tag Out procedures, as the first training module. Once developed, the module will be tested for effectiveness and assuming it is successful, the IN-MaC team will move on to creating additional training modules. Long term, the team plans to eventually create a library of these training modules that can be accessed by companies within the WHIN region and beyond.

Applying SMART Technology for Post-Pandemic Recovery

Purdue's Education Team held a series of DCMME-WHIN virtual Workshops featuring team presentations and a variety of WHIN manufacturers sharing information about their engagements with the Education and Supply-chain team. Workshop themes centered around SMART TP3, an approach designed by the team and the subject of a 2020 book based on enhancing manufacturing industry during the pandemic. This approach works with four key and mutually-leveraging aspects of manufacturing, namely, Technology, People, Product, and Process. Each Workshop was themed on one of these four aspects, along with an additional workshop focusing on 'Supply-Chain Resilience in the COVID Age.'

As more WHIN manufacturers consider SMART technology as a pandemic recovery approach, the difficulties in getting skilled staff, coupled with infection-control concerns, has made a number of technology solutions financially viable to smaller companies. These technologies include sensors, no-code apps, Value Stream Mapping with Infection (VSMI) for improved productivity and mitigation of infection-risks and data-analytics.

Manufacturers are widely interested in these technologies as evidenced by the projects that we have performed in partnership with various WHIN companies. The projects, several as case-studies, provided production solution directly impacting business' bottom lines. Their stories shared during the workshops provided narratives encouraging other local manufacturers to follow with their own technology adoption strategies.

Purdue presentation during the DCMME-WHIN virtual workshop.

Purdue-WHIN: Providing Low-Cost, Sustainable Solutions for Standard Industrial

Standard industrial, located in Winamac County, supplies a full line of industrial equipment and services for manufacturing.

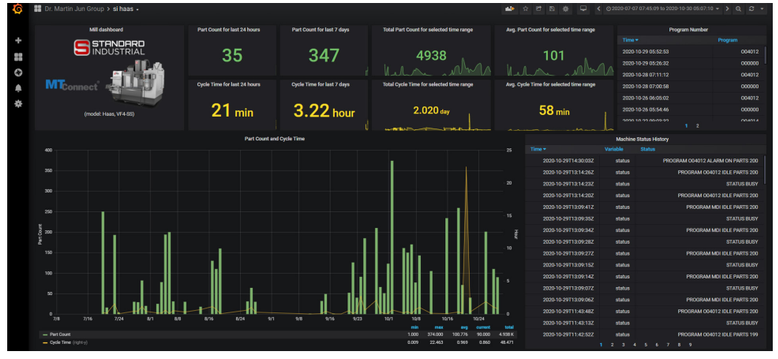
They supply machined parts such as bended pipes and sheet bended products to other local industries. Due to their various product types, machines from different vendors are used and their lifetimes are also different, which makes constructing a productivity monitoring platform costly. Legacy machines are designed to have machine data generated or collected and if not monitored closely, such machines are prone to unscheduled production downtime and costly repairs.

Standard industrial partnered with Purdue to find an affordable monitoring solution using opensource software, IoT hardware, and low-cost sensors. Professor Martin Jun and his graduate students have been working with Standard Industrial to provide low-cost and sustainable solutions for connecting their machines and collecting meaningful data as well as establishing a database for data analytics and visualization of the analyzed data. They utilized Raspberry PIs, small and low-powered computers to process data from the machines. By using a simple device from an operator's cycle start button, they collected data from a pipe bending machine. Another machine, a 3-axis CNC milling machine, was connected via Ethernet, collecting machine information. All the machine data is collected by MTConnect, accumulated to database, and Web dashboards were created to show the productivity information.

Purdue Student working at Standard Industrial.

All the information gathered is made visible to Standard Industrial using a Web-based dashboard made of Grafana, an opensource platform. Standard Industrial can monitor productivity information from anywhere and from any device. All of the hardware and software of the developed platform is IoT-based, low cost, low powered, and opensource. With the help of IoT and middleware technology, the collaboration with Standard Industrial shows that a small and mid-sized company having old machines can monitor productivity with less costs. In addition, this collaboration is enabling an innovative data analytics research initiative for a diversity of machines in a wide range of manufacturing industries.

Purdue's web-based dashboard used for Standard Industrial's milling machine.



THANK YOU!

We are grateful...

The Purdue-WHIN team would like to express its deep appreciation to the WHIN Board, the members of the Agricultural Board of Advisors, the Manufacturing Board of Advisors, WHIN staff, and all of the members of the 10-county region who are so integral to our work. We are deeply grateful to be part of such a unique endeavor, and your valuable expertise and guidance is vital throughout every step of this journey.

We are also eternally grateful to the Lilly Endowment, whose vision inspired this ambitious initiative and its generosity fuels its success.

WHIN helps Ivy Tech

With support from WHIN, Ivy Tech invested in an Amatrol Mechatronics Trainer in 2020. The device is intended to serve students studying Advanced Automation and Robotics Technology (AART) and Industrial Technology (INDT).

Because of the COVID-19 pandemic, those plans had to be put on hold. As restrictions ease, Ivy Tech faculty are preparing to bring the trainer online for students returning to in-person instruction.

The trainer fits on a tabletop, making it portable and easy to install. It is a foundational resource in Ivy Tech's WHIN testbed laboratory which serves the workforce training needs of manufacturers in the WHIN region.

The trainer allows the flow of a manufactured part through multiple production segments which use sensors such as RFID readers, a smart photoelectric sensor, smart analog pressure sensor, and IO-Link meter to integrate IoT applications in a hands-on training situation. Students will be able to learn how to collect data from the trainer in real-time and use the data for analysis when making actionable insights. They will also be exposed to the use of Programmable Automation Controls (PAC).

The trainer has been integrated within the AART/INDT program course work and serves students working toward a Mechatronics Level I Certificate, Technology Certificate, or an Associate of Applied Science (AAS) in Advanced Automation and Robotics Technology or Industrial Technology. Students who gain these credentials are prepared for opportunities in manufacturing maintenance and equipped with conceptual and technical skills in specific occupations.

Key Features of the Amatrol Mechatronics Trainer

- Teaches how to effectively operate, program, and troubleshoot complex automated equipment.
- Uses industry standard components typical of what learners will see in industry.
- Covers a broad array of applications across a balance of mechanical, electrical, electronics, fluid power and software to enable learners to work effectively in virtually any industrial setting.

prepare students for careers in next-generation manufacturing

Mechatronics Technician Jobs

According to *State of renewal: Charting a new course for Indiana's economic growth and inclusion*, published by the Brookings Institute in February 2021, the threshold salary for a "good job" in the WHIN region is $35,900. Brookings defines a good job as having employer-sponsored health benefits and being able to support a single person or two earner household.

According to ZipRecruiter, the average salary for a Mechatronics Technician in Lafayette and the surrounding area is $52,386. Though this is 7% below the national average, it is still well-above the good job threshold locally.

Mechatronics Technician jobs typically require an associate degree.

What is Mechatronics

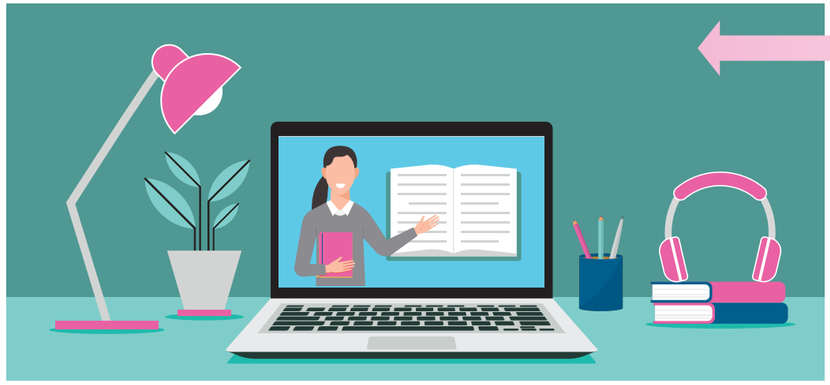
The term 'mechatronics' combines technologies in electronic systems, mechanical systems, control systems, and computers. Mechatronics aids in boosting productivity and efficiency while decreasing downtime and product waste among several advanced manufacturing applications. Time savings, increased output, and increasing cost-effectiveness can be realized when products are imaged, sorted, measured, and recorded as they move across a belt, rather than within different segments and locations.

About Amatrol (visit amatrol.com)

Amatrol is headquartered in Jeffersonville, Indiana. Originally a division of Dynafluid, Inc., which was an industrial automation system manufacturer serving Fortune 500 clients including Ford, Alcoa, GE, Chrysler, and Coca Cola, Amatrol is a leader in training products for next-generation manufacturing. The company provides interactive, online learning for the Manufacturing Skill Standards Council's (MSSC) Production Technician Certification training, and is a training partner of Siemens.

The Power of the Regional Cultivation Fund: **E-Learning**

WHIN is developing a model



WHIN's Regional Cultivation Fund (RCF) got off to a fast start with several exciting projects that addressed WHIN's RCF interest areas of education, vitality, and connectivity. But about a year ago, as the full impact of the COVID-19 pandemic was being felt, WHIN put the RCF to work solving the very difficult problem of e-learning.

E-learning is often reduced to a student broadband availability and accessibility problem, but it is actually an enormously complicated issue. Before the pandemic, many school corporations in the WHIN region had e-learning days for various limited reasons, including weather. But no superintendent had a plan to move delivery of curriculum wholesale to an online platform for all grades. The challenges were overwhelming. Adapting curriculum to a very different method of delivery; equipping and training teachers not only on technology but also on appropriate methods; and preparing parents and students for an entirely new way of learning, all had to be accomplished in a few short months.

And for many schools in our region, even through the worst of the pandemic, in-person classes were still offered alongside e-learning.

As one superintendent told us, it was like trying to manage two different school corporations with the same staff.

Still, not every school corporation in our region ramped up e-learning because of the pandemic. Even if a school corporation wanted to make more e-learning available, it did not have the resources to do so. Also, some had philosophical concerns about e-learning.

And then there was the student side of the equation: having enough broadband access to participate in e-learning should it be available.

Even student connectivity is not a simple problem because there are many reasons students don't have access. In a rural region like WHIN's, there may literally be no broadband service available, or if there is, it could be unreliable or not high enough quality to stream videos or participate in Zoom-style classrooms. In that sense, e-learning in rural communities is closely connected to the digital divide that plagues all aspects of community, economic development, and quality of life. Inability to deliver e-learning is just one more symptom, and many school corporations don't feel that the digital divide can and should be their problem to solve.

But in some areas, like urbanized Greater Lafayette as well many rural communities, available service may be adequate, but the cost is prohibitive for family budgets.

In the midst of preparing for the Fall 2020 semester, WHIN reached out to all 29 public school corporations, as well as to private schools, to introduce them to the program and to try to assess actual need.

WHIN brought several advantages to solving the problem in its highly diverse, large, complicated region

1) A regional footprint to create economies of scale and the use of shared resources.
2) The skill, experience, relationships, and resources to introduce innovative technology and creative approaches to solving an intransigent problem.

for multi-county rural e-learning

We then launched two pilots to exercise a process by which corporations would provide anonymized data at the student level that demonstrated actual need, along with demographics so that we would be able to develop profiles of whom we were serving.

The full RFP was released in January, 2021. As a result of all of our learning and piloting, the RFP was designed to be highly flexible, supporting school corporations wherever they are on the e-learning spectrum.

For example, school corporations have the option to purchase and distribute mifi devices, but we are also working closely with them to identify existing assets, like towers on schools, that could be provisioned within our or another network to provide high-quality wireless service to areas with large groups of students that need services.

Students may qualify because they do not physically have access to a network, their service is not adequate, or because they are economically disadvantaged.

We also included teachers who have no physical access in our program because that was often mentioned as a need that other grant programs are not meeting.

In the first round of WHIN's e-learning program, $2 million was allocated based on data submitted by the school corporations and on the proportion of students who are economically disadvantaged. Every school corporation received an allocation that they may use through the 2021-2022 school year. That amount is expected to serve 4,000-6,000 students.

As devices and other technology and services become available to students, WHIN will release funds from the allocations so that the school corporations can pay the bills.

Thanks to the WHIN program, we are also seeing school corporations reach out to each other to work together. WHIN's e-learning initiative is another part of the puzzle of solving the digital divide for our region.

County	School Corporation	2020-2021 Enrollment
Benton	Benton Community School Corporation	1,641
Carroll	Carroll Consolidated School Corporation	1,043
	Delphi Community School Corporation	1,397
Cass	Logansport Community School Corporation	4,274
	Lewis Cass Schools	1,336
	Pioneer Regional School Corporation	960
	Caston School Corporation	681
Clinton	Clinton Prairie School Corporation	1,212
	Clinton Central School Corporation	819
	Community Schools of Frankfort	3,152
	Rossville Consolidated School District	932
Fountain	Southeast Fountain School Corporation	1,024
	Covington Community School Corporation	827
	Attica Consolidated School Corporation	613
Montgomery	North Montgomery School Corporation	1,831
	South Montgomery School Corporation	1,647
	Crawfordsville Community School Corporation	2,546
Pulaski	Eastern Pulaski Community School Corporation	1,147
	North Judson-San Pierre Schools	953
	Culver Community Community Schools	758
	West Central School Corporation	668
Tippecanoe	Tippecanoe School Corporation	13,464
	Lafayette School Corporation	7,781
	West Lafayette Community School Corporation	2,316
Warren	Metropolitan School District of Warren County	1,310
White	Twin Lakes School Corporation	2,248
	North White School Corporation	842
	Tri-County School Corporation	749
	Frontier School Corporation	636
Total Enrollment		58,807
Economically Disadvantaged Students		28,345

It takes a lot of friends to solve such a big problem → **Thank you!**

North Central Health Services (NCHS) made a very generous $1 million grant to supplement WHIN's $5 million RCF investment.

The Richard M. Fairbanks Foundation has provided invaluable support, generously sharing its model and experience with a similar program in Marion County.

WHIN's regional Broadband Advisory Council and the region's LEDOs keep us connected with community plans, needs, and opportunities for connectivity.

APPENDIX A: **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.	• The new wing of the Agriculture & Biological Engineering buliding opened to the public in December 2020, as scheduled. The 160,000-square-feet space was designed to be very welcoming to the community. The lower-level floors focus upon teaching and applied research. The basement space houses classrooms and teaching labs. As the building progresses higher, the research becomes less applied. Though Purdue is still in remote learning mode, classes commenced in this widely sensored, high-tech facility in January 2021.	100%
Twenty demonstrations and/or teaching initiatives per year.	• During this six-month reporting period in the midst of COVID restrictions, Digital Ag Specialist John Scott conducted 40 UAV flights: - 10 partnering with industry - 5 partnering with Ivy Tech - 25 for Purdue Extension/Purdue research in the WHIN region	100% of target (70% 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. Somali Chaterji has filed two patents with the Office of Technology and Commercialization (OTC); both technologies are now open for licensing. A third disclosure was recently filed (more details to come in the next report). Dr. Chaterji recently published a paper on benchmarking computer vision workloads and was interviewed by Data Skeptic (a top machine learning podcast: http://bit.ly/Janus-benchmarking-IoT)	100% of target (150% of goal over 5 years)
$3.5 million of research expenditures in the testbeds from industry and government sources, post-sensor installation.	• Several industries have supported the ABE facility/testbed with $250,000 of investments during the past six months. These include: Microsoft, Centricity, InfoSys, Winfield, and CNH.	8%

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).	• Enabled by WHIN's extensive instrumentation, ACRE hosted 60 participants from the WHIN region for a crops field day and presentation on field scouting. At this event, Ivy Tech students learned how to use a UAV rate calculator to set the seeding rate for cover crops.	100%
Twenty demonstrations and/or teaching initiatives each year.	• Site visit and planning is complete for Microsoft FarmBeats at ACRE installation. LoRaWAN base station enclosure was designed/procured in September. FCC license was approved in October. A new test stand was built and deployed by one of the WHINterns in January 2021.	97%

AIM 3.1.1.B *(Cont'd)*		
Proposals submitted for three community-linked research projects connected with the facility per year, post sensor installation.	• Met with Purdue Ag IT about their LoRaWAN deployment at ACRE and to coordinate with them on WHIN's LoRaWAN deployment. Met with Melba Crawford to discuss Intelinair Imagery and tie-ins with hyperspectral imagery research going on at ACRE. Provided the 2021 ACRE sample dataset to Purdue.	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.	• $300K grant was funded for Growing the Workforce for Digital Agriculture, Agriculture and Food Research Initiative (AFRI), Professional Development for Agricultural Literacy (PDAL) Priority Area Program, 2021-2023. Erickson and LaRose are the Principal Investigators (PIs).	43%

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.	• There have been two sensors installed and collecting data since September 2020 from the Realm5 company. A second weather station serves as a connectivity gateway for the sensors. The first sensor installed is called a "Flex" sensor, which is a soil temperature and moisture sensor. The second sensor is called a "Furrow" sensor, which monitors soil moisture and is installed 16 inches underground. This type allows a farmer to till over the top of the sensor. Both sensors are located via GPS for tracking purposes. Teralytics sensors to monitor soil nutrients (NPK) and soil carbon have been ordered and anticipated arrival and installation in Spring 2021.	100%
Proposals will be submitted for 4 community-linked research projects connected with the laboratory per year, following the sensor installation in conjunction with Purdue University.	• A collaborative proposal between the Purdue Department of Agronomy and the Ivy Tech Precision Ag Equipment Technology program was funded in December 2020 by USDA NIFA Workforce. Bruce Erickson from Purdue will take a lead role with Ivy Tech assisting in an advisory role. The project, currently in process, will create curriculum for train-the-trainer programs with high school teachers teaching precision agriculture in their programs. • Purdue and the Ivy Tech Department of Engineering and Mechanical Engineering have also collaborated on a proposal to the NSF titled "Systems Thinking: Undergraduate Student Preparation for Industry 4.0." This proposal was submitted in November 2020. • There has been progress made with the USDA NRCS cover crops trial project. The cover crops were seeded using a drone and was demonstrated to the students. The cover crops will be complementary to the soil nitrate sensors to be installed by the Purdue Birck Sensor Team, as well as the Teralytics soil nutrient sensors. • WHIN and Ivy Tech continue to make progress on the awarded $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 WHIN Interns created a Digital Agriculture Web Application Research and Compilation for a Purdue Extension Resource Repository (John Scott collaboration). The team of WHIN Interns also conducted comprehensive MiFi testing throughout the 10 county region to document connectivity. WHIN has also worked with Ivy Tech faculty to facilitate data transfer from WHIN Alliance weather stations and MFG facilities through the WHIN Data Portal.	66% of target

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 eight additional weather stations and 17 3G weather stations were retrofitted to 4G LTE capability. In addition, Telesense has been onboarded as a new tech partner, and MakuSafe is implementing a pilot project with WHIN later this year.	60%
Ten counties throughout the region will be engaged each year in community-linked IoT platform projects or training.	• WHIN continues to deploy and monitor IoT sensors through its Tech Partners in the Ag and Manufacturing Alliances. The Broadband Alliance is continuing to develop the Aerostat project with RTO Wireless. RCF grant recipient NCIRPC/WATCH Communications has prepared and shared with the LEDOs a propagation map to provide an engineering plan to reach 85% of households via fixed wireless in the WHIN region. WATCH identified 11 locations to deploy LoRaWan gateways providing coverage in each of the 10 counties. LoRaWAN is a long-range, low-power, low-bandwidth communication that allows IoT devices to communicate to the cloud (for example, a soil moisture and temperature sensor in a farm field).	70%
$.5 M of research expenditures in the testbeds from industry and government sources.	• WHIN has received investments from tech partners totaling an additional $200,344 in this six-month period, for a grand total of $971,497.	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.	100%
Twenty-five BS graduates per year in digital agriculture.	• First offering last fall of AGR33300 Data Science for Agriculture yielded 7 completing the course, the most possible with COVID room restrictions. Fourteen are enrolled in Spring 2021. Two more students graduated in August 2020 and three in December 2020 with a BS that included at least four digital agriculture courses, bringing the total to 48 to date. Many courses were completed successfully despite COVID19 disruption.	100%
Fifty certificates per year awarded on digital agriculture topics.	• Sixteen certificates were awarded to adult learners who successfully completed the spring 2020 offering of Precision Agriculture, one of the four courses in Purdue's Agronomy e-Learning Academy. Enrollments are up 50% in the Academy by year-to-year comparisons since WHIN's implementation.	100%
Eight professional MS degrees per year awarded in digital agriculture.	• Five students graduated in December 2020 with an MS or PhD that included digital agriculture as part of their thesis. This brings the total number of graduates to 19 since the beginning of the WHIN grant.	100%

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.	• Digital Ag Specialist John Scott presented or co-presented several webinars, including "Making Sense of Sensors" (with 20 participants and 136 views), WHIN-Purdue Ag Advisory Roundtable event (with 11 attendees), UAV Uses in Livestock (with 45 participants and 51 views).	100%

AIM 3.1.5 *(Cont'd)*		
Investment in a marketing campaign to brand Purdue Extension as the primary and trusted source of information on science-based digital agriculture innovations.	• During this six-month period, Professor Dennis Buckmaster finished the Digital Ag App database and presented his findings to the WHIN-Purdue group, laying the foundation for recommendations for future Extension-related products to inform, educate, and increase access to resources. In addition, he recorded a video covering digital ag tools, including drones, weather stations, nitrate sensors, and available apps. This semester, his Data-Driven Agriculture webinar series is underway with 55 regional stakeholders attending each week.	85%
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).	• Digital Ag Specialist John Scott conducted three flights (over Happy Hollow, Tapawingo, and the Celery Bog) for Purdue Agronomy courses to digitize some of their field trips due to COVID restrictions. He also presented on UAVs to the AGRY 498 Precision Ag class (in-person) with Dr. Keith Johnson (with 11 live and 13 online participants).	80%
Adoption of digital agriculture strategies by at least 15 rural communities, agribusinesses, co-ops, and/or ag-related nonprofits by 2022.	• Digital Ag Specialist John Scott made presentations throughout the 10-county WHIN region during four of the six previous months, despite COVID. These presentations included: 200 Pasture Weed Management virtual trainees, 111 Pesticide Applicator Reapplication Program live trainees, 37 Purdue Extension educators, 26 White County Winter School attendees, 15 WHIN region residents, two Purdue researchers, two school district meetings, and two farmer meetings.	80%

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.	• Testbed infrastructures are complete and several research and demonstration projects are underway, including: predictive and preventative maintenance through IoT, model-based work instructions, product data management, and technical cost modeling. In the past six months, additional investments have been made in roll-to-roll thin-film manufacture (in collaboration with Birck/WHIN-IoT). In spite of coronavirous restrictions virtual conferences were hosted at the Testbed featuring collective WHIN-Manufacturing efforts. A series of 1-hour virtual workshops are planned for Spring semester. The WHIN-Manufacturing team continues to visit manufacturers across the region to develop and implement field projects. The testbed has hosted small groups of manufacturers in IMI to showcase its capabilities, introduce technologies to participants, and explore collaborative project areas. A public launch of the Testbed facility is scheduled in the second half of 2021 if community health guidance allows.	100% of target (90% of goal over 5 years)
Establish IMT Testbed to showcase IoT sensor/network capabilities to companies and students.	• Strategic relationships with industry service providers aid in extending Testbed capabilities and resources to manufacturers across and beyond the Wabash Heartland. Since the commencment of WHIN, the collective value of discounts, gifts, and services from industry partners is approximately $800,000 from industry leaders including: IFM Efector, Kennametal, Flexxcool, Blauser, Sage Clarity, Haas, Fetch Robotics, Fanuc, GoogleX, and Hexagon/eXstream.	100% of target (70% of goal over 5 years)
Establish additional technology adoption opportunities through mobile demonstrations.	• WHIN-Manufacturing continues to expand an industrial implementation program (I2P) for manufacturers who seek to enhance or increase in-house digital transformation capabilities. In coooperation with IN-MaC, these projects have been launched or completed in the past six months at WHIN companies including: Engineering Improvement Services, C&D Industrial, Kirby Risk Advanced Machining (in partnership with Birck Nanotechnology Center), and Tate & Lyle. The scope of the projects include: advanced machining services, IoT field deployments, and digital technologies for training. Steps are underway to further extend industrial implementation projects across the region, including at CAT, Evonik, and Tate & Lyle.	100% of target (75% 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 applies a suite of digital and cloud-based tools and applications within its digital architecture. The research team has identified and studied a number of use cases through the 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 research focus that is planned to extend beyond the Testbed as a field project with Drug Plastics and Glass (Benton County) in the summer of 2021. This project digitally aligns model-based aspects of design, production, and use of product data across the supply chain for improved quality control.	90%
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 collaborate on IoT sensing of a manufacturing system in the Testbed (machine kinematics, 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 subtractive equipment 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. • These IoT projects have been a central aspect of WHIN-Manufacturing research and field studies with manufacturers in the region (Standard Industrial, Tate & Lyle, Drug Plastics, Evonik, and Biotown Ag). Plans are underway through the jointly created Purdue Manufacturing Gateway (PMG) to strengthen industry access to Purdue competencies. These efforts have further extended work in the first half of 2021 to other manufacturers in the Wabash Heartland, including Kirby Risk and CAT.	100% of target (70% 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 is applied to develop technologies and methods for industry. WHIN-Manufacturing researchers have conducted field work at 14 WHIN companies, including testbeds that remain active at: Drug Plastics (Benton), Standard Industrial (Pulaski), Tate & Lyle (Tippecanoe), BioTown Ag (White), C&D Industrial (Fountain), and Voestalpine (Tippecanoe). • Planned activities to further extend Purdue expertise into companies in the WHIN region include: a collaboration with Birck, IN-MaC, and WHIN-Manufacturing researchers to install IoT sensors at Kirby Risk Precision Machining and CAT (Tippecanoe) during Q2 2021.	90%
Deploy and assess the digital product and process information model with partner companies and their supply chains.	• Through a collaboration with WHIN, the Indiana Manufacturing Competitiveness Center (IN-MaC) is partnering with Tate & Lyle and Evonik have developed training modules for onboarding new employees or refreshing current employees. The training focuses on factory processes that are common to most companies, regardless of their industry sector. One example is the Lock Out/Tag Out procedure, which is often part of safety training at a company. Once the module is developed, it will be tested for effectiveness, and assuming it is successful, the IN-MaC team will move on to creating additional training modules. Long term, the team will create a library of these training modules that can be accessed by companies within the WHIN region and beyond.	90%
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 deployed several IoT sensor platforms. Researchers study the barriers to digital interconnections across the Testbed and are deploying product data management (Aras) and manufacturing execution systems (Solumina) through Q2 2021 for Testbed research and demonstration product lines.	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. These studies apply IoT sensors and data collection platforms for a variety of real-world contexts then utilize machine learning and other methodologies to contextualize, display and provide inferences from the data. WHIN-researcher work has been tested in the IMI testbed, at Birck and in the FLEX lab and extended to a variety of WHIN-companies including: Drug Plastics (Benton), Evonik (Tippecanoe), Standard Industrial (Pulaski), Biotown (White), Tate & Lyle (Tippecanoe), and several other locations.	100% of target (70% 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.	• A new attribute called, "materials used," was added to the Digital Supply Chain Tool (DSCT) database that will give important insight into capabilities of the supplier companies. This new attribute was added to the similarity analysis and identified other ways the supply chain tool can be utilized by procurement managers at companies, adding attributes such as square footage, annual sales, and revenue.	70%
Connect with LEDOs or other economic development groups across WHIN counties to deploy supply chain prototyping tool.	• Continued to attend Indiana Technology Corridor (ITC) and Workforce 2030 meetings where all 10 county LEDOs gather and visiting LEDOs one-on-one in their individual counties. Ongoing presentations about the WHIN Education website and the supply chain tool portal are given frequently to regional stakeholders, including LEDOs. Launched a new initiative to partner with the LEDOs to provide tools and assistance for them to attract new businesses to the area.	100%
Work toward expanding the Digital Supply Chain Tool to include specialized suppliers.	• Additional NAICS codes were added to the Digital Supply Chain Tool (DSCT) as discussions continued with users, companies, and LEDOs, gathering feedback on supply chain tool utilization. In the past six months, the DSCT portal has been searched 1,602 times by regional stakeholders.	50%
Work with OEMs to prioritize approaches to reduce supply chain leakage and record extent of leakage reduction.	• Started discussions with companies about the import data represented by Harmonized System (HS) Codes indicating the high volume of products being imported from outside United States. This discussion leads to discovering opportunities in the region for reducing supply chain leakage and boosting economic activities.	100%
Work with individual companies to seek opportunities to collaborate to go after new business.	• Continued working with a group of companies to explore opportunities to use import data in the following ways: 1. Reshore purchases from overseas countries 2. Identify alternative countries that may be better sources 3. Consider consolidating purchases via 3rd parties to leverage higher volume purchases by combining volumes across multiple companies	100%
Expand deployment of supply chain prototyping tools at LEDOs or other entities.	• Working with specific companies to realize their needs and how the supply chain tool can benefit them. Also inquiring about what features would serve them best.	100%
Deploy supply chain prototyping tools as Web-based resources to attract new manufacturing investments to the WHIN region	• After the launch of the supply chain tool, now all WHIN companies have access to tool with personalized login. The LEDOs have personalized logins for the supply chain tool as well. Scheduled one-on-one meetings with the LEDOs to train for the optimal use of the supply chain tool.	60%
Work with procurement managers at OEMs to implement usage of supply chain prototyping tool.	• Conducted data analysis for the products imported by companies at the county level for LEDOs in the WHIN region by HS Code. Met with LEDOs for initial conversation and to showcase the results from the import data.	60%

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

Anticipated Outcomes	Outcomes to Date	%
Ivy Tech will develop campus-based curriculum, and work in conjunction with the Krannert School of Management and IN-MAC, in developing online curriculum.	• Recent IoT and LoRaWAN equipment purchases for ITCC faculty have informed new on campus curriculum for our IT Department to be completed and integrated into courses Spring of 2021. Ivy Tech continues to work on the Purdue Education Portal, a project spearheaded by the Krannert School of Management to list and promote course offerings. Ivy Tech continually monitors to ensure the web portal contains its latest offerings and meets bimonthly with Krannert staff to identify additional opportunities for collaboration.	100%
The first year of the grant will be focused on fostering greater collaboration between ITCC and Purdue in terms of IoT expertise and student need assessment.	• There is a regular cadence of meetings that take place bimonthly between Ivy Tech and Purdue's Indiana Manufacturing Institute (IMI).	100%
Year 2 will focus on recruiting students and setting up the sensored lab in preparation for the pilot.	• The WHIN intern team and Ivy Tech students continue to be engaged with the teaching lab. The Ivy Tech Agriculture Teaching Lab in Lafayette continues to be widely sensored and is now adding Teralytic Ag soil sensors to the mix of technology being explored in the field. Teralytic sensors provide soil nutrient and carbon levels. Ivy Tech has begun early conversations about installing "smart drainage tile" technology for managing wet areas of the field. This system utilizes subsurface sensors to monitor water levels in the tile, allowing the grower to manage the release or retention of the water in the field through blocking or releasing the water in the tile. This system could possibly tie into the existing sensors and nitrate sensors to be installed by Purdue's Birck Nanotechnology team.	100%
Years 3 & 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).	• Sixty-four student interactions were recorded during the fall 2020 semester in Ivy Tech's agriculture program, as well as another 30 student interactions in Ivy Tech's manufacturing program. The unique student interactions represent course enrollment in Agriculture (AGRI), Precision Ag Equipment Technology (PAET), Informatics (INFM), Network Infrastructure (NETI), Advanced Automation, and Robotics Technology (AART). Before this six-month period, 102 student interactions were recorded (55% of goal), but these additions bring the total to 196 of the 240 goal (or 82% of the goal) for student interactions through year five.	117.5% of target (82% of goal over 5 years)
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.	• During the fall of 2020, the WHIN Intern Team conducted MiFi speed data collection throughout the entire 10-county WHIN region. This data will inform the WHIN Broadband Initiative as to the levels of data speeds from three major cellular service providers, including: AT&T, Verizon, and Sprint. A map was created to visualize the data speeds at several coordinates around the 10 counties. • The fall 2020 WHIN Intern Team also collected information to comprise a repository of Digital Agriculture resources across the Midwest available to farmers. This repository will be used for Purdue Extension programming, and will also identify potential gaps in resources available for farmers seeking Digital Agriculture information, particularly from land-grant university sources. Another team of four WHIN Interns has been hired for summer 2021, resulting in a total of 12 interns to date. The WHIN Intern team will be working on documenting the positive impacts of sensors installed within regional industries.	60%

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.	• Working with Greater Lafayette LEDO to create a customized training program on the Education Portal to provide unemployed and underemployed persons access to free online training to better prepare them for entry-level manufacturing jobs.	100% of target (60% 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).	• Conducted a December workshop to highlight the Purdue-WHIN Education and Supply Chain activities during 2020. Over 60 participants engaged to watch multiple videos presented on the TP3 framework: Technology, People, Process, and Products. Recorded 314 visits for the WHIN education website in the month of December.	100%
Implement communication plan that includes WHIN web-site and periodic newsletter.	• Bulletins have met the needs of engaged company contacts during the pandemic better than the presently-postponed newsletters. The bulletins are faster to access (concise, one-line subjects) and provide only go-to information that makes a practical difference to companies' declared needs. A significant number of companies have either been swamped with more orders and struggling to find good people to hire or suffering from significant drops in orders and struggling to gain business and re-hire workers. A leading shift in support has been to help companies leverage their businesses during the pandemic. The applied learnings from our independently published book, 'SMART Manufacturing, The New Normal – A TP^3 Strategy' have been made available by launching a series of workshops (with our own team presenting as well as corporate facilitators), all providing success-narratives to encourage others. We have new and updated websites for training needs, supply-chain leverage; and, our own independently produced onshoring tool to bring overseas supplies into the local industry. Other tools have included VSMI to improve the bottom line and mitigate against SARS-CoV-2 infections. We have also promoted a new certification instrument to encourage up-skilling in both work skills and cultural behavioral norms, to make the in-house re-deployment of staff more effective (and work to standards), when other employees cannot work.	100%
Design curriculum around the content most needed by employees (as exposed in the gap analysis) to increase their "value creation ability" and productivity.	• In addtion to continuing to add new courses to the Education Portal, a new program section has been added to encourage participants to take a series of related courses that when completed will result in certification.	100%
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.	• We are testing whether local businesses are ready to re-engage with the SMART Technology Special Interest Group (and also, seek a straw poll of the potential for re-starting other non-competitive groups including Regional Developmental Groups).	100%
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 non-competitive Regional Development groups and Special Interest Group activities are all suspended due to the pandemic. We will continue to keep in close contact with our key contacts to make informed judgement calls about restarting and increasing the number of Special Interest Groups (to include Data Analytic tools and applications as well as other identified technology areas that are know to be hot interests with our target companies). We are assessing our short-list of these technologies with key company contacts now.	100%
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%

AIM 3.2.5 *(Cont'd)*		
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 10 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).	• A new Power BI training program will roll out in March to promote the implementation of business analytics. This is a very topical issue across many companies.	85%
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).	• Currently engaged with multiple companies to develop customized courses for their employees. This appears to be an effective option for HR departments. • Currently working with multiple companies to engage in small project learning opportunities. One example is "Cobots." We plan for every part and research locations for new service centers. Recorded 442 visits for the WHIN education website in the month of February.	100% of target (60% 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.	• Our ag IoT nodes include commercial soil moisture and temperature as well as low-cost sensors for nitrate concentration measurements. Experiments with silver-based electrodes showed a long-term effect of water-layer formation affecting sensitivity. We have developed an alternative carbon-based technology that shows better performance and longevity. We are optimizing the readout electronics of the ag IoT node for the new sensor technology.	100%
Fabricate two dozen sensors for lab characterization and field test.	• Six hundred silver- and 780 carbon-based ion selective sensors were fabricated for a variety of lab and field experiments. In-line characterization of the sensors and imaging have been used to develop machine-learning algorithms to improve manufacturing quality control. New algorithms reduce sensor variability and have resulted in a provisional patent application and a few papers.	100%
Finalize the design of water sensors for Purdue's Water Quality Field Station.	• Low-cost nitrate sensors were tested at ACRE WQFS to optimize the electronics and networking and to compare to ground truth experiments. During the winter months, we validated the robustness of our networks in harsh outside conditions.	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.	• We have deployed IoT manufacturing networks at several locations, including Birck Nanotechnology Center and Indiana Manufacturing Institute, that monitor temperature, humidity, and vibration sensors. The data of these deployments are available through user-friendly visualization pages. Our next step is to integrate pressure-sensitive sensors at these locations and at our new deployments on manufacturing floors.	90%
Study aging and drifts.	• The deployed manufacturing networks are mainly based on commercially available sensors that have minimal aging and drift. We are developing a low-cost flexible vibration sensor solution to complement these deployments and are in the process of acquiring data on the aging and drift to assist on the design process and data analysis.	80%
Test pressure sensors at 3-5 local manufacturers.	• The team is currently finalizing development of MEMS-technology vibration sensors before moving into sensors measuring pressure. We have deployed MEMS vibration sensors at three manufacturers (Evonik, Drug Plastics, and BioTown Ag) and we also have deployments of acoustic pressure (i.e. microphones) for machine-module uptime and analysis at BioTown Ag.	100%

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).	• We are obtaining data from our Ag nodes at eight IoT nodes: - Birck Nanotechnology Center - TPAC - ACRE - Ivy Tech - Benton County farmers (three locations) - Warren County farmer • We have manufacturing nodes at six IoT networks: - Birck Nanotechnology Center - Indiana Manufacturing Institute - BioTown AgEvonik - Drug Plastics - Voestalpine • Overall, we have sensor networks in 15 locations (including one residential location where we test new sensors and protocols).	100%
Guest lectures (K-12, community colleges, local businesses).	• Due to the COVID restrictions, number of in-person meetings were very limited. We organized a seminar with a group of eight engineers from Evonik where social distancing was possible. We provided an in-depth review of capabilities and benefits of our IoT sensor deployments and Machine Learning in the manufacturing environment. We received valuable feedback and comments that help us develop workshops for other manufacturers in the region. In December, two virtual manufacturing and ag conferences from the Purdue-WHIN team provided an overview of the latest activities in ag and manufacturing sensors and IoT development, testbeds and regional deployment, data visualization, and analytics. About 80 industry collaborators and guests attended the conferences. Finally, in January, we presented in the open session of the SMART Industry meeting which had 65 participants, including 33 representatives from 18 companies across the United States, increasing the visibility of our activities.	100%
Help community testbeds with IoT sensors, data network, and data analytics.	• The IoT team installed a commercially available network of low-energy Bluetooth sensors monitoring vibration, temperature, and current. Custom-made, open-access visualization for these sensors was enabled, allowing implementation of machine-learning algorithms for predictive maintenance and cost analysis, and demonstrating a paradigm of installation and data visualization and analytics platform for the community. A more extended installation integrating a variety of wired and wireless sensors has been deployed at the Birck Nanotechnology Center. The manufacturing portal is directly accessible at https://purduewhin.ecn.purdue.edu. Lastly, we installed a powerful LoRaWAN gateway (Kona Mega LoRaWAN gateway, Tektelic) on the roof of the Birck Nanotechnology Center for extended coverage of the Discovery Park location and the west side of the Purdue campus.	90%

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 hosted three major events, including: - WHIN Annual Meeting (115 attendees) - WHIN Manufacturing Summit (52 attendees) - WHIN Ag Alliance Summit (61 attendees) • In addition, they have leveraged nearly $500,000 ($476,499 to be exact) by establishing regional partnerships.	65%
There is better alignment between regional education and workforce efforts, yielding more youth and adults prepared for employment.	• Three Regional Cultivation Fund grants (Tecumseh Area Partnership, MSD of Warren County, and IWA of Montgomery County/Ivy Tech) have moved the needle significantly in terms of regional education and workforce alignment.	70%

AIM 3.4.2 : Educate the Region's Future Workers

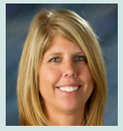
Anticipated Outcomes	Outcomes to Date	%
Implementation of I-STEM curriculum into the 26 elementary schools in the region without comprehensive, research-based science, technology, engineering and math curriculum.	• In the past six months, the Tecumseh Area Partnership (TAP) has reached 1,808 elementary school students with STEM programming like Manufacturing Week and Robotics camps in all 10 WHIN region counties. A total of 17 elementary schools have been involved in this programming, nearing the original goal of involving 26 elementary schools.	65%
Implementation of Project Lead the Way (PLTW) into the 22 middle and high schools without research-based science, technology, engineering and math curriculum.	• In the past six months, the Tecumseh Area Partnership (TAP) has reached 1,008 middle school students with STEM programming, such as Manufacturing Week and CoderDojos, in all 10 WHIN region counties. A total of 14 middle schools and 17 high schools have been involved in this programming, exceeding the original goal of involving 22 middle and high schools.	100%
3,000 high school enrollments in STEM career education courses region-wide (from the baseline of 1,558 current high school enrollments).	• In the past six months, the Tecumseh Area Partnership (TAP) has reached 1,690 students at with STEM programming like Manufacturing Week, in addition to the 1,242 students reached during the last reporting period, for a current total of 2,932 students reached to date.	98%
750 "STEM-Ready" high school graduates (who have taken at least 1 STEM-related course).	• Seeger High School had 33 high school students graduate in May 2020 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).	• As a result of the Indiana West Advantage/Ivy Tech Precision Ag grant, 5 students enrolled in the Precision Ag program at Ivy Tech in spring 2021.	1%

AIM 3.5: Cultivation Fund

Anticipated Outcomes	Outcomes to Date	%
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 WHIN Board approved a $300,000 commitment of RCF funds for Rural Entrepreneurship Programs and allocated another $5 million to assist schools with e-Learning connectivity. This investment will impact all 10 counties in the Wabash Heartland region.	35% ($3.4 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.	• The WHIN Board approved an RFP e-Learning project for the 10-county region, and WHIN was approved to receive a grant from North Central Health Services (NCHS) to help with this e-Learning project, in addition to the RCF funds.	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.	• PCRD deployed a Remote Work and e-Learning survey to coordinate with WHIN's new RFP efforts in August 2020. Nearly 300 regional residents responded to that survey and a report with key findings was delivered to the WHIN Administration for review in February 2022.	100% of target (60% of goal over 5 years)

APPENDIX B: **Biographies**

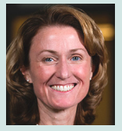
WHIN Board (MEETS BIMONTHLY)

	**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.
	**Natasha Cox**	Regional Vice President for Farm Credit Mid America in Lafayette. Leadership roles include Indiana Corn Marketing Council Board of Directors, Purdue Center for Commercial Ag Advisory Board, Indiana Department of Ag Advisory Board, Indiana Certified Livestock Producers Advisory Board, Ag Alumni Seeds Board of Directors, and Ivy Tech Lafayette Campus Board of Trustees.
	**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**	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**	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, Agribusiness Council of Indiana, and Clinton County 4-H Council.

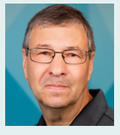
Purdue Leadership (MEETS QUARTERLY)

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

Ivy Tech Leadership (MEETS QUARTERLY)

	**David Bathe**	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**	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, Agribusiness Council of Indiana, and Clinton County 4-H Council.

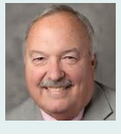
WHIN Staff (MEETS WEEKLY)

	**Johnny Park**	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
	**Greg Jarman**	Vice President of Broadband Partnerships.
	**Ted Fiock**	WHIN-Purdue Managing Director.
	**Chad Martin**	WHIN-Ivy Tech Project Manager.
	**Zach Mason**	Senior Software Engineer.

WHIN Staff (Cont'd)

	**Audette Taylor**	Director of Finance.
	**Shawn Johnson**	Senior IoT Solutions Engineer.
	**Alivia Roberts**	Marketing and Communications Manager.
	**Josh Karshen**	Member Success Manager.

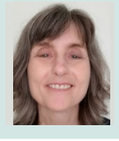
WHIN-Purdue Operations Team (MEETS MONTHLY)

	**Ali Shakouri**	Mary Jo and Robert L. Kirk Director of Birck Nanotechnology Center; Professor of Electrical and Computer Engineering.
	**Jan-Anders Mansson**	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**	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**	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**	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**	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.
	**Saurabh Bagchi**	Professor of the College of Electrical and Computer Engineering and Co-Lead of the Purdue-WHIN IoT group.

WHIN-Ivy Tech Operations Team (MEETS MONTHLY)

	**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.
	**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**	Vice Chancellor of Academic Affairs.

APPENDIX C: Frequently Used Acronyms

AART.....Advanced Automation and Robotics Technology

AAS.....Associate of Applied Science

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

ACM.....Association of Computing Machinery

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

AR.....Augmented Reality

CICP.....Central Indiana Corporate Partnership

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

DSCT.....Digital Supply Chain Tool

ERC.....Engineering Research Center

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

IMT.....Intelligent Manufacturing Testbeds

INDT.....Industrial Technology

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

IoT.....Internet of Things

IWA.....Indiana West Advantage

LEDO.....Local Economic Development Organization

MSSC.....Manufacturing Skill Standards Council

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

NCHS.....North Central Health Services

NCIRPC.....North Central Indiana Regional Planning Council

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

OTC.....Office of Technology & Commercialization

PAC.....Programmable Automation Controls

PAET.....Precision Agriculture Equipment Technology

PCRD.....Purdue Center for Regional Development

RCF.....Regional Cultivational Fund

RFID.....Radio Frequency Identification

RFP.....Request for Proposal

RTO.....Rural Technology Operators

TPAC.....Throckmorton-Purdue Agricultural Center

UAV.....Unmanned Aerial Vehicle

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

WHIN.....Wabash Heartland Innovation Network

Wabash Heartland Innovation Network
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WHIN.org