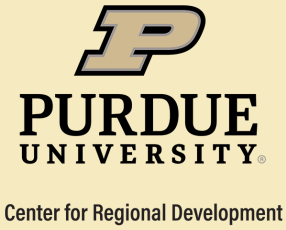
Ripple Effects Mapping:

A Value-Added Process for Documenting the Impacts of the WHIN Initiative

PURDUE UNIVERSITY | Center for Regional Development

Acknowledgments



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The Purdue Center for Regional Development (PCRD) has been involved in the Wabash Heartland Innovation Network (WHIN) since 2016 as the research/assessment component of the project. PCRD has provided WHIN with grant-writing assistance, a comprehensive data dashboard, regional place-making surveys, biannual reports, a set of three midpoint impact analysis reports and this Ripple Effects Mapping report.

Ripple Effects Mapping: A Value-Added Process for Documenting the Impacts of the WHIN Initiative

The following section of this report focuses on the launch of the Ripple Effects Mapping (REM) process conducted in the WHIN region in the early months of 2022 and the results of the important sessions held with key stakeholders/participants in the region.

Introduction

One of the activities that has been a part of the Wabash Heartland Innovation Network (WHIN) has been its investment in the design and implementation of a sound process for tracking the progress and documenting the impacts of the multi-pronged WHIN effort in the region. The Purdue Center for Regional Development (PCRD) was charged with the responsibility of guiding and implementing several facets of the WHIN evaluation plan. To ensure the evaluation would produce sound, unbiased and accurate information, the PCRD evaluation team embraced a multi-method approach to its evaluation plan. It included the following:

Creating the WHIN Region Data Dashboard:
Baseline data on the WHIN region is important since it provides valuable information and insights on the socioeconomic and demographic features of the region at early stages of the WHIN effort. As such, PCRD produced a data dashboard for the purpose of developing a better understanding of the human capital assets and core economic drivers of the region.

Launching Resident Surveys:
To help gain a pulse of the key local needs from the perspective of local residents, PCRD conducted "placemaking" surveys that helped identify areas where targeted investments by WHIN or other key partners could be pursued.

Conducting Key Informant Interviews:
At various points along the way, interviews with key informants were conducted by PCRD for the purpose of assessing what was working well and what improvements might be needed in terms of the efforts of the various players engaged in WHIN. This process was important since it provided WHIN the opportunity to introduce adjustments along the way to maximize the effectiveness of WHIN's activities.

Tracking Key Metrics:
Several of the Purdue-based units with an active part in WHIN – especially the entities with a major focus on advanced manufacturing, digital agriculture and IoT sensors – developed a series of outputs and outcomes they established as key goals to be realized as a result of their WHIN-related activities. PCRD tracked the output/outcome metrics on a monthly basis through a multiple-reporter online survey (powered by Qualtrics) as a way of documenting the multiple impacts of their work in the WHIN region.

With the culmination of the initial phase of the Lilly Endowment's investment in WHIN approaching, PCRD wanted to find a process that could help capture the overarching benefits of WHIN through the lens of regional stakeholders from the 10 counties where the work took place. One of the options that best met the needs of the PCRD team is a process called Ripple Effects Mapping (REM) (Chazdon et al., 2017; Kollock et al, 2012).

The "What" and "Why" of Ripple Effects Mapping

Ripple Effects Mapping (REM) represents an innovative tool for capturing qualitative information from individuals who are positioned to shed light on the important impacts that specific programs may have had on the intended beneficiaries of such activities. An important strength of the REM process is its ability to assess whether the expected or intended goals of certain programs were ultimately realized. But the value-added aspect of the process is the capacity to document unexpected outcomes of programs, in addition to positive changes that may have been achieved as a result of trusting relationships that individuals, industry representatives, and/or communities may have developed over the course of such programs (Olfert et al., 2018: Welborn et al., 2016).

The main reason why REM makes sense for the WHIN effort is that it builds on the information and data that have been collected by PCRD and other WHIN-related groups over the course of the initiative. As noted above, the WHIN Data Dashboard and the set of key metrics being collected on a routine basis from various WHIN teams are helpful in producing sound quantitative information. Furthermore, the key informant interviews being conducted are instrumental in gathering the inputs and insights of individuals – but on a one-to-one basis. REM, on the other hand, seeks to effectively engage small groups of people in fruitful discussions of the larger set of impacts that might have emerged from WHIN. Simply put, the REM strategy helps paint a more complete picture of the overarching benefits of WHIN – both anticipated and unanticipated – on WHIN's intended audiences. It does so by blending multiple information gathering methods – small group interviews, group brainstorming, visual mapping of positive outcomes/changes, and the careful synthesizing of qualitative information – to detect major themes and the rippling effects associated with these thematic areas (Emery et al., 2015).

The REM Methodology: An Overview[1]

Conducting a Ripple Effects Mapping (REM) session requires a good amount of preparatory time on the part of the people organizing and hosting each event. As **Figure 1** shows, one of the first decisions was to decide on the central focus of the session(s). While the WHIN project involves a number of activities, the REM effort was intended to focus on "the pillars" of the WHIN initiative – Advanced Manufacturing, Digital Agriculture and Regional Cultivation – with IoT sensors undergirding the efforts of all three. Next, the format for the REM sessions had to be determined. Should the sessions be conducted on a face-to-face basis, virtually (using the Zoom platform), or some combination of both formats? In light of the demanding schedule of the proposed REM participants, it was decided that most sessions would be conducted virtually, with an option of hosting a hybrid session (one combining both face-to-face and online participants in a session).

Figure 1. Conducting a REM Session: Key Steps

[1] This section draws on articles by Chazdon et al., 2017 and Welborn et al., 2016)

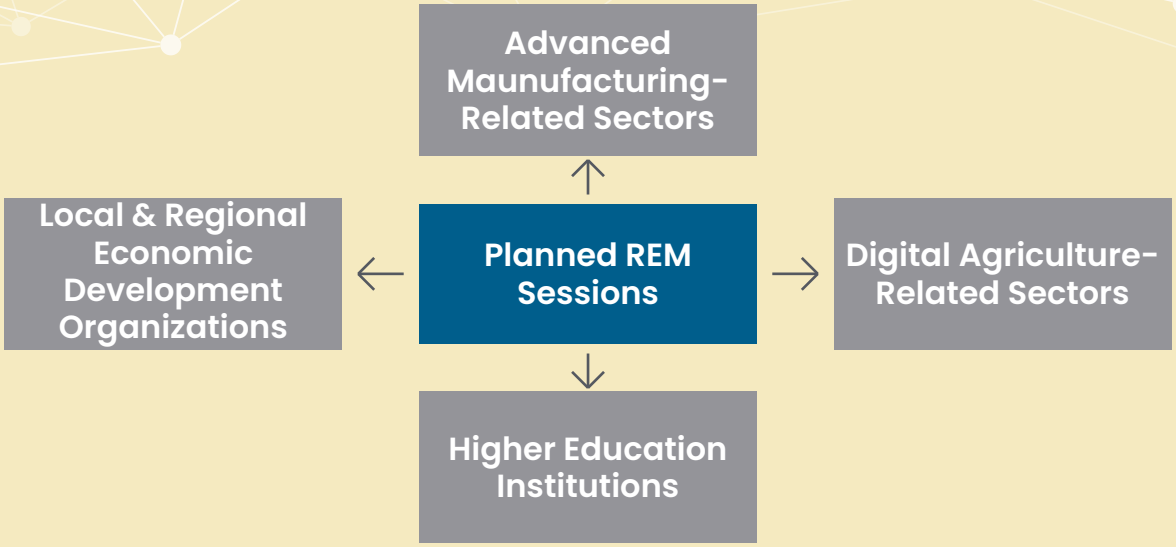
Determining Who to Invite?

Once the focus and format had been decided, the next step was to generate a list of top candidates to be part of the REM session and subsequently, to invite them to be part of the group activity. Individuals being targeted were knowledgeable of the initiative with an interest in sharing their insights as to the anticipated and unanticipated outcomes and/or impacts of the WHIN effort in the region. As such, the planned REM sessions targeted representatives drawn from the Advanced Manufacturing and Digital Agriculture sectors, as well as grant recipients of the Regional Cultivation Fund (RCF). Individuals who guided and supported the innovative work (primarily those from both Purdue University and Ivy Tech Community College) were invited to participate in a special hybrid session, so they would not influence the participation of the regional stakeholders during the other REM sessions. The plan was to complete seven REM sessions in order to ensure that a diversity of people and voices were heard and that a more complete picture of the impacts of the WHIN initiative could be captured.

Conducting the REM Sessions

Without question, one of the exciting steps in the REM process is hosting sessions with small groups of people who are positioned to share their perspectives of activities undertaken as part of a project, program, or larger initiative. However, securing useful information from REM participants is no easy task. It demands advanced work on the part of a well-trained team of professionals who are seasoned in terms of facilitating a REM session and who, simultaneously, have a good working knowledge of the initiative being discussed with participants. In this case, PCRD chose to hire two expert facilitators, Dr. Debra Hansen and Dr. Lorie Higgins, as neutral parties who were not involved in the initiation or execution of the LEI grant award to WHIN. Furthermore, REM requires the development and administration of a well-sequenced set of questions that engage session participants in a positive and productive brainstorming discussion of the initiative serving as the centerpiece of the session. (Questions used in the REM sessions are included in the appendix.) It is the discussions and interactions among participants that help produce the "raw data" needed to map the expected and unexpected outcomes evolving from the initiative. (Olfert et al, 2018; University of Minnesota Extension, n.d.)

Figure 2. Target Groups for the REM Sessions



Mapping the "Raw Data": Some Options

The most valuable product emerging from the REM sessions are the story maps that take shape as those participating in these small group discussions share their "juicy bits". These stories are crafted from the raw data collected in the various REM sessions, including the so-called ripple effects –- actions that represent spin-offs of certain planned interventions. The primary value of the stories is that they provide a more in-depth understanding of the key takeaways associated with the program, project or initiative being examined (Mouillesseaux-Kunzman, 2021).

There is no "one way" to build the important stories from the information provided by the REM participants. Rather, there a variety of mapping approaches that can be considered, and they include the following:[2]

1. Web Mapping:
REM participants deliberate on the short-, medium-, and long-term impacts of an intervention and visually mapping these out. If appropriate, these outcomes can be classified into certain categories based on well-accepted conceptual frameworks. For example, one often employed framework for coding the information generated from REM sessions is the Community Capitals Framework, one that assesses the extent to which interventions have strengthened and/or expanded any of the seven capital assets in the community/region of interest (Floras, etc.).

2. In-Depth Rippling:
The REM sessions hone in on the most significant impacts associated with an initiative and details the series of activities that contributed – both directly and indirectly – to these important outcomes.

3. Theming and Rippling:
The information garnered from the REM sessions are analyzed and synthesized into major themes. Next, the impacts and ripple effects associated with each of the themes are mapped.

4. Mapping the ABCs:
Attention is given to the nature of the shifts that may have occurred in the attitudes/knowledge, behaviors, and conditions on the part of people, organizations, communities, and/or regions being targeted as part of a program or initiative.

5. Private/Public Value:
The goal is to begin by mapping what people are doing differently, then detailing who has benefitted from the intervention and in what specific ways. Finally, the changes local groups and community institutions have made in the way they do things are noted in the map. It is this last question that seeks to identify the public value/benefits associated with specific interventions.

Reporting Results

The final step in the REM process was the completion of a report. In this case, the document being prepared was intended to provide the initiative's funders with some valuable qualitative information on the value and impact of the effort from the perspective of those who were its primary beneficiaries. A secondary audience for the report are the regional stakeholders themselves – the local people, organizations, communities and counties that constitute the WHIN Region. For either of these audiences, it is important to present findings in a user-friendly manner so that the results can be fully understood by both audiences and serve as a catalyst for more positive actions to be launched by them in the future.

The format for preparing the report is typically guided by the approach (described in the previous section) selected by the team hosting and/or conducting the REM sessions. For example, if the decision is made to

[2] This section draws on the following articles: Emery et al, 2015; Washington State University Extension, n.d.; Trickett & Beehler, 2017; and Haskell et al., 2019.

highlight major themes and the ripple effects associated with each of the themes, then the report would be presented in this manner. In the case of the WHIN initiative, for example, one theme could have been to explore in greater depth the work targeted to the Advanced Manufacturing sector or the region. In this case, a portion of the report would describe the principal outcomes/impacts of this work and then map the ripple effects associated with these impacts – including additional activities and outcomes that were unanticipated and were the direct or indirect product of WHIN's advanced manufacturing activities. Instead, the WHIN REM team chose to follow the pattern established in the midpoint impact report that aggregated to the theme of "If Not for WHIN…" under the categories of innovations, initiatives, investments and networks.

Multiple Benefits of REM

Ripple Effects Mapping (REM) represents a valuable addition to the evaluation toolkit the Purdue Center for Regional Development (PCRD) has deployed as part of its formal evaluation activities for the WHIN initiative. Unlike the other evaluation strategies being pursued (described in the introductory section of this document), REM enriches our understanding of the "so what?" when it comes to the work of the WHIN team. Rather than depend strictly on quantitatively-driven statistics, REM helps build a more complete picture of WHIN's impact, doing so by capturing the stories from the perspective of the primary and intended beneficiaries of this initiative (Mattos, 2015).

Evaluation professionals who have developed and/or employed REM in their work have noted some of the key benefits associated with the REM process. They include:[3]

Flexible:
REM can be used to track progress (and guide needed adjustments) and/or collect outcome/impact information once the program/project has been fully implemented

Provides Visual Picture:
As REM participants share their thoughts of the important activities launched as part of a given initiative, the session facilitator or co-facilitator visually maps these outputs and outcomes. Mapping serves as an effective tool for both engaging participants and showcasing the rippling effects associated with that initiative

Untangles Complex Outcomes/Impacts:
Any initiative launched in a community or region can produce a host of outcomes. REM helps untangle which of these outcomes are consistent with the goals of the initiative and which impacts are totally unexpected or unanticipated

Gives Voice to Stakeholders:
Conducting REM sessions affords many stakeholders with the opportunity to share their insights on the positive things that have happened as a result of a project, program or initiative

Efficient and Cost-effective:
REM helps generate important information can be secured from participants in a timely fashion at a minimal cost to the sponsor or session organizer

Energizes Stakeholders & Others:
More often than not, stakeholders are not fully aware of the positive activities and changes that have resulted from a planned project, program or initiative. But REM helps record the multiple activities and actions that have stemmed from an initiative and in so doing, spurs stakeholders and other local/regional individuals and groups to continue building on that momentum.

[3] This section draws on the following articles: Olfert et al., 2018; Ritchie et al., 2013; Hansen et al., 2018; University of Minnesota Extension, n.d.; Daniels et al., 2016; Emery et al., 2015; Welborn et al., 2016; and Kollock et al., 2012.

Concluding Comments About REM

Ripple Effects Mapping (REM) represents a well-respected social sciences-based process that is founded on such works as asset-based community development (Kretzmann & McKnight, 1993), appreciative inquiry (Mathie & Cunningham, 2003), and community capitals framework (Flora & Flora, 2013). As such, it is a valuable addition to the evaluation strategies PCRD has been pursuing in its quest to produce a sound, comprehensive and unbiased assessment of the value and impact of the WHIN initiative in the region.

The following three sections of this report (Next-Generation Manufacturing, Digital Agriculture and Regional Cultivation Fund) are based on feedback from more than 50 participants in REM sessions and respondents to key information questionnaires. Here, we highlight some of the interactions, initiatives, innovations and investments that exist now in the Wabash Heartland Region that would not have otherwise … if not for WHIN. Then, we finish up with concluding comments focused on lessons learned and other takeaways from this work that will help us answer the question, "What's Ahead?"

Next-Generation Manufacturing Ripple Effects Mapping (REM) Sessions

Two sessions were held with representatives from the manufacturing sector in the WHIN region. A subset of participants was directly engaged in manufacturing education activities while others were engaged in manufacturing technology activities. Their insights are captured under three major headings: (1) Organizational Strategies & Activities Connected to WHIN; (2) Projects Initiated as a Result of WHIN; and (3) the Ripple/Catalytic Effects Linked to WHIN.

I. Organizational Strategies & Activities Connected to WHIN

1. Reducing the Industry/Academia Gap

The manufacturing leaders taking part in the two Ripple Effects Mapping (REM) sessions had high regard for the innovative and impactful work being conducted by a variety of academic units at Purdue University. The most significant challenge they often have experienced, however, is how to gain entrée into Purdue and to the right people at Purdue who could help industries located in the region. In the WHIN manufacturing sector alone, the WHIN-Purdue team has executed more than 75 projects with a variety of manufacturers. The majority of these manufacturers (approximately 75% or more), have been small / medium-sized enterprises that prior to WHIN have had very limited or no exposure to the assets available to them through Purdue University.

As one session participant noted:

> *Purdue is a massive entity; how do you work with people that really have the intelligence and research in the areas where you're having concerns and problems? And where do you go and how do you get that contact?*

The WHIN initiative was partially designed for – and certainly instrumental in – opening pathways for linking up with the "brain trust" located on the Purdue campus. It did so by lowering the barriers between manufacturing leaders in the region and Purdue faculty, staff and students.

> *I think it was getting into the room… just creating those personal relationships, creating trust with each other, because that's where relationships are formed -- through that trust. And from there, it is just having real conversations with each other about where we're at, where we can help them, and where they can help us.*

Not only did this phenomenon occur for Purdue as a result of the WHIN project, but also for project partner, Ivy Tech Community College. Educators and researchers from both institutions (Purdue and Ivy Tech) reported a much stronger collaboration as a result of the five-year WHIN initiative. Ivy Tech faculty members specifically said:

> *We had deeper conversations with Purdue than we would've had otherwise. The agriculture side already has a "pathway" between the two-year to the four-year degrees. Our manufacturing side does not – or had not, up until this point. Without the WHIN grant, we wouldn't have had those conversations. Those relationships wouldn't have been created.*
>
> *We cultivated that collaborative transfer because of the trust that was started and cultivated over four years. We've developed a new program within our school – not necessarily because of WHIN since it was really a statewide initiative. But, because of our relationship as partners in this grant, we brought cyber security networking expertise in from Purdue.*

The end result is that the manufacturing and WHIN representatives (from WHIN-Purdue, WHIN-Ivy Tech and WHIN) have operated on an equal playing field, acknowledging and respecting the views of each group and working in concert to find possible strategies for solving the many challenges manufacturers in the region are experiencing.

> *I think the biggest gain that we had was just the ability to have a platform to where we could come together and have conversations. And, I know that may not necessarily be the goal of the WHIN project. But, it was a platform to collaborate and just bounce ideas off each other. And we got small manufacturers in the room at the same time with giant global manufacturers. In some cases, they had the same problem, but not the same resources to solve them.*

Purdue leveraged the initial WHIN grant from Lilly Endowment Inc. (LEI) for a total of $6,413,000 in additional investments in next-generation manufacturing initiatives and innovations. WHIN-Purdue raised $1.77 for every WHIN dollar invested, resulting in a 76.7% return on investment (ROI).

2. Strengthening Networks/Promoting Collaboration

As mentioned above, bridging the gap between industry and academia is dependent, in part, on building trust between these two important entities. From the very early stages of its activities, WHIN embraced the view that networking and collaboration were two essential ingredients for building trust. Industry representatives taking part in the REM session stated that WHIN served as a conduit for promoting conversations and supporting partnerships among manufacturers, prompted by Purdue/Ivy Tech faculty and WHIN professional staff and students. The WHIN-Purdue team has documented over 11,000 regional engagements since the launch of the WHIN grant.

These connections promoted open, honest and respectful discussions as to the needs of industries and the ability of the educational institutions to respond to these requests. One manufacturing representative commented:

> *We have expanded both our industrial leader's network, as well as our education networks. This has resulted in networking lunches as well as site visits. We have a regular seat at the WHIN Manufacturing Alliance table and have been updated on all the new technology that impacts our industry. The manufacturing conversations that regularly take place are very valuable. The*

opportunity to connect with new start-ups that can offer solutions and help troubleshoot within the daily operation schedule is another big support.

At the same time, it offered Purdue/Ivy Tech researchers and practitioners the opportunity to share information on new products or services being tested, as well as how they might reduce costs, promote greater efficiencies, or improve decision-making by the manufacturing sector.

While not all manufacturers were positioned to work with the WHIN-Purdue, WHIN-Ivy Tech team or WHIN Tech Partner teams in pilot testing some of these innovations, the discussions helped plant seeds as to the possible adoption of these innovations at some point in the future.

Ivy Tech developed a system, internally, for fielding WHIN-generated requests from local manufacturers. One Ivy Tech faculty member said:

> *What happens is: You get comfortable talking to a specific person. The role of Ivy Tech's Career Coaching & Employer Connections (CCEC group) is to be the eyes and ears of the community. So, if an employer has a need, whether that be Excel training, or if that is a hands-on skill or whatever, we have one person who is a contact for that employer. As a result, I know I am very, very involved with the manufacturers at this point.*

3. Offering Students "Real World" Experiences

Students from Purdue and Ivy Tech (through their WHINterns program) were provided valuable opportunities to work hand-in-hand with representatives from the region's manufacturing sector. In many instances, students were introduced to the nuts and bolts of an industry's operations, including plant layouts, handling and flow of plant materials, assembling pieces of equipment, packaging materials, transporting logistics, and more. These real-world experiences were value-added opportunities for these students, activities that complemented their formal coursework and gave them insights as to the multiple facets of manufacturing. The WHIN-Purdue Team estimates that 350 Purdue students have been engaged in the region in various agriculture, manufacturing and IoT projects since the launch of the WHIN grant.

One postdoctoral student is a prime example of this value provided by WHIN:

> *I was working with [a professor] at Purdue directly on a manufacturing-related project, coordinating all the different efforts. That was my role until seven days ago when I started a similar position with a consulting firm in Chicago. I don't think I would have taken this new position if it wasn't for WHIN because over the last five years, I've been introduced to various industries and the issues they encounter. It was refreshing to be able to solve the "real-life" problems that are relevant to them [industry leaders] versus thinking about it from just an academic perspective. WHIN also gave me an extensive network of like-minded, progressive manufacturers and researchers to draw upon for future collaborations.*

4. Accelerating Adoption of New Technologies

The first step to adoption is awareness – and that's where WHIN's efforts began in the Wabash Heartland Region by introducing manufacturers to a concept called Industry 4.0[4]. As organizers and stakeholders of this effort have often joked, no one knew how to spell IoT (short for Internet of Things) before the WHIN initiative was launched in 2018. While the main focus of the WHIN grant was IoT adoption, during the early days of the grant, it became apparent that the majority of manufacturers, especially small / medium-sized enterprises (referred to as "SMEs") were not ready for IoT adoption. Many of our projects with these local firms assisted them with entry-level technology adoption, solving immediate needs, while exposing them to the higher-level technologies, thus encouraging them along the pathway forward.

According to this WHIN region manufacturing representative, focusing on awareness made a big difference to him and his company:

> *The WHIN project has exposed my company to Industry 4.0 – something I was completely unaware of before. They not only present information, but they also offer solutions through the WHIN Manufacturing Alliance.*

In terms of the impact of awareness regionwide, one manufacturer had this to say:

> *As much of the industry in this region was lagging on Industry 4.0, my opinion is that WHIN has moved the needle forward in a significant way. Although manufacturing may still not be at the pace of agriculture, the WHIN initiative has definitely brought it to top of mind with a larger group of manufacturers undertaking adoption or pilot steps.*

WHIN was instrumental in helping inform and guide the potential adoption of new processes and strategies that could prove beneficial to manufacturers in the region. One of the manufacturers who participated in a Ripple Effects Mapping session, noted:

> *I can't tell you how many times I've gotten a call out of the blue from [a representative] from DCMME with WHIN-Purdue. And the individual says, "Hey, you know that problem you were telling me about a couple months ago with XYZ. I think I've got a solution for you. I've got a group... we can get together and work on that for you. It's very easy with all the different organizations they work with, to just move on to the next person. But they keep... taking good notes, I guess. And, they continue to go back and look for those solutions and don't let things just go away.*

Two different manufacturers expressed their gratitude by saying:

[4] See https://www.mckinsey.com/business-functions/mckinsey-digital/our-insights/the-next-horizon-for-industrial-manufacturing?cid=eml-web

> *Three plus years ago I was assigned to a facility in the WHIN region. I am very grateful that the WHIN-Purdue team made contact with me. I have been able to develop valuable relationships that have allowed us to stay ahead of the curve with technology for manufacturing. The connections I made within the Purdue, DCCME, and IN-Mac Institute communities was directly attributable to our enrollment in WHIN. Those resources and connections allowed us to further accelerate several IoT and 4.0 projects that provided ROI (return on investment). This includes our work with IoT on our Heat Treat and Finishing lines, as well as being able to provide direct machine data on performance and asset health in our assembly and inspection facility.*
>
> *There are two projects that are currently underway that have been positively influenced indirectly by WHIN. These have slowed down a bit to the supply chain challenges within the metals industry, but without WHIN would likely not have begun.*

WHIN, WHIN-Ivy Tech and the WHIN-Purdue teams provided a safe place to converse with industry leaders about new technologies for manufacturers that prove viable for some companies. These included discussions of data collection and sensor-technology enhancements that could be cost-effective if adopted by some of these enterprises. One manufacturing representative taking part in one of the REM sessions offered a succinct statement as to the valuable role WHIN played in tailoring innovations to the unique needs of companies:

> *WHIN came in with a very specific focus . . . how do we really deploy IoT-type capabilities in this region for the specific purpose of improvements . . . in manufacturing? And then, narrow that even further to say, okay . . . you have specific challenges in each of these areas . . . and here are some things that we can do from not only conceptualizing how to solve the problem, but here's a specific technology and . . . some equipment that will help you do exactly this.*

5. Serving as a Third Set of Eyes

It was not uncommon for REM participants to make note of the fact that their time, energy and attention is often focused on their company, working to help manage and operate their enterprise in a manner that aligns with the rules, practices and culture of their company. This tendency to devote near-exclusive attention to their firm had made it difficult, they stated, to see the big picture of possible changes or minor tweaking that could be made with respect to the technologies or other innovations being deployed by their company. As such, the WHIN team served as an independent set of eyes, viewing the activities of the manufacturing companies in a new light. One statement made during the course of the REM session captures this notion of the value of a third set of eyes:

> *They came in and helped look at some things and say, I know you've tried this, but have you approached it from a slightly different angle? Why can't you do something with this technology that you already have in place?*

6. Providing High Quality Facilitation

WHIN has devoted a good bit of time organizing and bringing together a variety of individuals in the region to provide input, guidance and/or serve on committees having a focus on such matters as manufacturing, agriculture, broadband, human resource management, and more. Securing valuable input, insights and feedback from these various constituencies does not happen by accident. It requires a team of skilled facilitators who can design and implement a systematic process for ensuring that meetings are focused and intended to generate useful information. To many of our manufacturing representatives engaged in the REM sessions, the quality of the facilitation provided by the WHIN team was instrumental in "holding their feet to the fire in a positive way." The facilitators guided the group in setting up future meetings on specific dates, and without fail, helped the group to generate great ideas and action plans. What started off as peer groups, has now branched out to special interest/user groups. These groups, convening around such topics as Power BI, Human Resources, Cobots, etc., now engage more than 70 members from WHIN region manufacturers.

As one participant remarked:

> *Without that impetus [provided by the facilitators], I'm not sure on our own we would collectively call nine people together and say . . . let's get together for lunch and talk about that. So, I think it's a big role in facilitating . . . and I think it's an asset that WHIN provided that was really helpful.*

Manufacturers also found value in touring each other's facilities because it gave them the opportunity to see a different perspective on a similar product or process. One manufacturer shared:

> *Out of all the different plants we went to, I could definitely go through and say, "There's something there that I would like to take back." And at some point, we would like to be able to implement something like that in our plant - and have those goals out there in front of us - because we were able to do that networking and get those groups together.*

Several industry leaders within the 10-county manufacturing footprint noted during their REM sessions or key informant interviews that the "WHIN magic" really happened because they "took action together." One manufacturing representative specifically said:

> *If we get together and share, that's good. If we can get into something small, that's actionable, it's really good.*

They shared that the "big secret" to success has been non-competing firms collaborating around common problems. The Peer Network groups organized, facilitated and managed by WHIN-Purdue through the Dauch Center for the Management of Manufacturing Enterprises DCCME) is a prime example of this type of effort. Over the five-year period, these Peer Network groups have included nearly every manufacturing enterprise – big and small – in the 10-county Wabash Heartland Region.

II. Projects Initiated as a Result of WHIN

1. Launching Projects Tailored to Local Manufacturers

The relationship-forging and trust that was built between the WHIN team and key manufacturing stakeholders helped to identify and tackle projects of high importance to manufacturers in the region. Six projects are showcased in this section of the report.

a. Data Mining

The application of sensors and other Internet of Things (IoT) applications represents one the important innovations WHIN has been introducing to manufacturers in the region as a result of Lilly Endowment's investment in the region. A few companies in the region were early adopters of smart manufacturing applications prior to the launch of WHIN. When WHIN representatives began engaging in discussions with manufacturers, it became abundantly clear that some of these companies did not have the capacity or the right personnel to mine the collected data – or the wherewithal to digest and interpret the data. So, one valuable support the WHIN-Purdue and WHIN teams provided was data mining expertise for those seeking that type of assistance.

For example, working in collaboration with Purdue faculty and students, one company was able to meet and work with up to seven students and two faculty members over a span of several months, delineating a scope of work, meeting on a regular basis with students, securing feedback/updates from students, and getting together to review results to date. That company's representative stated in a REM Session, "... something that would have taken us six months to a year [to complete] took them [the students] one to two months." Data mining is a valuable expertise that Purdue and WHIN brought to manufacturers in the region.

b. Sensors (IoT) Project

The members of the manufacturing sector taking part in the REM sessions were knowledgeable and supportive of all the work the WHIN team has done to accelerate the use of sensors by companies in the region. They stated that sensors have been invaluable when it comes to cutting-edge abilities, like predictive maintenance. WHIN's tech partners have made an impact for Manufacturing Alliance members like this one who said he has deployed smart sensors throughout his facility as a result of WHIN's influence:

> *These sensors will have a huge impact on showing overall equipment efficiency, notifying our maintenance department when service is needed, and getting our runs times dialed in for more accurate quoting. We have been a WHIN Manufacturing Alliance member since WHIN began and have had both the Fluke vibration and temperature sensors and Machine Metrics OEE software deployed. Both of these solutions have been beneficial in making critical business decisions such as when to purchase a new piece of equipment or when to perform preventative maintenance.*

Other WHIN region manufacturers said:

> *With labor and material constraints, resources are a luxury and we can't afford scrap in any step of our processes. Overall Equipment Efficiency (OEE) and Predictive Maintenance are two areas in manufacturing where controlling resources can improve efficiency in our processes.*
>
> *Everybody knows that predictive maintenance and sensors are already available in advanced Computer Numerical Controls (CNCs) that we have. But we were looking for more, we are not only looking for the maintenance feedback, but also for operations feedback on an ongoing and continuous manner with engineering feedback. So, we were kind of looking at it from three different ways. When we put sensors on our equipment, the WHIN group came over and helped us analyze it -- and we started getting tons of data, which is always the key in this thing.*

Other smart manufacturing projects that have emerged within the past five years, as well, such as these two mentioned by a WHIN region manufacturing representatives:

> *We were able to generate a couple smart manufacturing projects around IoT and Power BI, leveraging existing proximity (PLCs) and edge sensors. With the assistance of a couple of Purdue post-docs, we were able to develop the reporting structure to make IoT data available in real-time and in Power BI to key stakeholders.*
>
> *As a result of WHIN, my company is now developing a project with IN-MaC to see if we can detect product failures on our manufacturing machines. We have engaged our process engineers to identify how concepts like OEE and predictive maintenance can be automated and applied to our specific circumstances.*

While progress has been made when it comes to the adoption of sensors by various manufacturers, some REM participants are looking for more. Specifically, they need operations feedback on an ongoing continuous basis as well as engineering feedback. For instance, it was noted that the sensors they have in place are providing information on a 10-minute basis, but the value of the sensors would be greater if data were produced on an ongoing basis. They recommend the redesign of the sensors that provides continuous feedback to the firm. As one participant summarized:

> *How do we collect [data] to get real world outcomes that our maintenance group, our production group, and our engineering group can use . . . to help us become a better company and manage that piece of equipment much better?*

c. Inventory Turnover Ratio System

According to Oracle NetSuite[5], the inventory turnover ratio represents the number of times a company has sold and replenished its inventory over a specific amount of time. One manufacturer in the region stated that his company was having a difficult time tracking the amount of inventory they had on hand, including both excess

[5] See https://www.netsuite.com/portal/resource/articles/inventory-management/inventory-turnover-ratio.shtm

> *. . . not only did the project that they did [the WHIN-Purdue students] develop our ability to understand our inventory turns at a local level and drive . . . excess and obsolete [inventory] out of our system, it actually started another project we're working with some grad students on right now. . . From our standpoint, we're going to save significant dollars, not only in labor, but . . . on the productivity side.*

d. Marketing Project on Electric Vehicles

One firm in the region has partnered with a team from the Dauch Center for the Management of Manufacturing Enterprises (DCMME) to conduct marketing research for the company. Since the firm was not large enough to have its own marketing division, the WHIN-Purdue team from DCMME represented a valuable asset to the company (and region). Because of the growing interest and importance of the electric vehicle (EV) market, the company is examining what role they might be able to play in the EV supply chain in light of the products its manufactures. The hope is that the company might be positioned to produce charging stations for use in parking garages and other commercial/industrial settings.

e. Digital Energy Management

A recent endeavor between the WHIN-Purdue team and one of the local manufacturing companies is focusing attention on digital energy management. While still at the early stages of development, the goal is to pursue data science at a large scale, but doing so with data secure system. If successful, the project will result in a sustainable regional energy improvement initiative.

f. Digital Supply Chain Tool (DSCT)

According to the Purdue Center for Regional Development (PCRD) data dashboard (available on WHIN.org under the Resources tab[6]), the manufacturing industry in the WHIN region in 2018 had a total supply chain demand of $5.57B. But only $0.81B (or 15%) of the demand was supplied within the region, which led to a supply chain leakage of 85 percent. WHIN believed one of the ways to reduce the leakage was to provide a Digital Supply Chain Tool (DSCT) that would allow the companies in the region to easily identify potential suppliers by specific capabilities and requirements needed for the job. One local economic development official (LEDO) had this to say about the value of this regional, searchable database now referred to as the DSCT:

> *I think that not all IoT solutions are for all companies. However, I know that for our local manufacturers, they have picked and chosen the solutions that make sense for them. I also think that the continued efforts in supply chain -- and keeping as much business within the region as possible – has been a great addition to the WHIN initiative.*

g. Robotics

While efforts toward automation began before COVID, the global pandemic gave this a huge push. With the labor pool drastically affected by COVID, those facilities who had been exploring automation solutions with WHIN pre-pandemic benefitted post-pandemic. Two manufacturers relate their experiences:

[6] See: https://pcrd.maps.arcgis.com/apps/MapJournal/index.html?appid=3f180338dd524069bd6d8d043516796f

> *We are currently working with IN-Mac/WHIN-Purdue on developing a co-bot packing system at the Indiana Manufacturing Institute (IMI) facility. We are also involved in several student projects and have deployed student teams for analysis review of positions and functions.*
>
> *While we were fairly automated already, we still needed to look at some of the lingering functions that still demanded human interaction. The co-bot testbed project has not directly benefitted our operation - yet. However, it has been extremely successful in the development phase. Our vison of what we want to do is coming to a reality – sparked by WHIN. We feel confident that we should see the co-bot system on our floor by year-end or before!*

The Ripple/Catalytic Effects Linked to WHIN

As was noted in the introduction on Ripple Effects Mapping (REM) process, the value of this qualitative method is that it helps document outcomes that WHIN was seeking to achieve in the region, but also those activities that were not expected or anticipated. These constitute the ripple or catalytic effects associated with WHIN's activities. We highlight three such effects that were captured in the REM session with representatives of the manufacturing sector.

1. Mentoring of Purdue Students

As was noted in the introduction on Ripple Effects Mapping (REM) process, the value of this qualitative method is that it helps document outcomes that WHIN was seeking to achieve in the region, but also those activities that were not expected or anticipated. These constitute the ripple or catalytic effects associated with WHIN's activities. We highlight three such effects that were captured in the REM session with representatives of the manufacturing sector.

> *The mentor side of things has actually helped me to a certain degree . . . I love the input they gave me and the interactions [we had with them]. Moreover, it was not uncommon for students to take part in an exit interview and to be asked if the experience working with the company proved beneficial to them. While several students were destined for careers in management, the students often stated that getting on-the-job experiences reading blueprints, detailed drawings, and assembling information needed by their mentee, were of great value to them.*

2. Promoting Information Sharing Among Manufacturers

It is not uncommon for manufacturers to play it close to the vest when it comes to sharing information with fellow manufacturing firms in the WHIN region, especially companies that may be direct or indirect competitors. Here, the value of facilitating and convening can't be overstated. Manufacturers are willing to meet and share their ideas/experiences with others when an environment is created for such engagement. The initial metric for the Purdue-WHIN manufacturing team was to engage with 77 companies in the WHIN region. To date, they have engaged three times that number (236 companies).

With respect to data mining or the application of new technologies by some manufacturers, the question they had to wrestle with is whether they would share results with other manufacturers in the region. One REM participant shared the following:

> *Let's say we're successful, and we find some interesting things in our data, would we be okay with that being shared with a larger audience? We're moving ahead knowing that this could help others, whether it's a competitor or just a general industry at large.*

The consensus among those in the REM sessions was that the networking and collaboration that was strengthened, in part, by the various WHIN activities, made it easier for them to share relevant information with other firms in the region. Certainly, the trust and social capital they built as part of their engagement with various WHIN activities removed the barriers to the sharing of such information.

The following observation offered by one of the industry representatives captures the central message the group of participants wished to convey:

> *I think we all just kind of realized [that] it's okay to share some of this stuff because the technologies are all things that would be beneficial to all of our companies. . . It's not that we have to worry about the specific things that we do as companies, but . . . how do we apply the common technology that's now becoming readily available?*

3. Tackling the COVID Challenge

The onset of COVID-19 in early 2020 had a pervasive impact on a number of businesses, including the region's manufacturing sector. Because of the working relationship that some firms developed with Purdue faculty and students and WHIN professional staff as a result of WHIN, they reached out to these various WHIN entities for help. In fact, in the midst of the global pandemic, the WHIN-Purdue manufacturing technology team quickly pivoted to help supply the region with 48,000 pieces of PPE serving both front-line medical personnel and the campus community.

> *Known as the Purdue's Boiler 'Maker' team, this ambitious campus-wide initiative was led by a professor with the Indiana Manufacturing Competitiveness Center (IN-MaC). Boiler 'Maker' encompassed more than 40 faculty, students, and staff from at least six colleges and six centers across campus who effectively launched a PPE start-up in less than three weeks. Every piece of PPE developed went through the IN-Mac's Intelligent Manufacturing Testbed (IMT), funded by WHIN, for final packaging, tracking, and delivery. A number of PPE items were designed and produced there as well.*

One of the REM participants mentioned that his company worked with the WHIN-Purdue team, out of DCMME, on a new value stream mapping (VSM) method, one that incorporated social distancing protocols, for which Dr. Ananth Iyer, and collaborators Steve Dunlop, Roy Vasher and Angus McLeod, wrote a book, Smart Manufacturing – The New Normal: A TP3 Strategy[7]. He said:

> *We collaborated with that group quite a bit at the onset of the pandemic on how to handle manufacturing in a pandemic environment. And that was extremely useful for us because … we can't do [manufacturing] work from home.*

[7] See: https://www.amazon.com/SMART-MANUFACTURING-NEW-NORMAL-Strategy/dp/B08GLST6TW

Figure 3. Ripple Effects Mapping - Maufacturing Sector Sessions

Primary Effects

Organizational Strategies & Activities

Reducing Industry/ Academia Gap

Strengthening Networks/ Promoting Collaboration

Offering Students "Real World" Experiences

Accelerating Adoption of New Technologies

Serving as a Third Set of Eyes

Providing High-Quality Facilitation

Project Activities

Launching Projects Tailored to Local Manufacturers

Data Mining

Sensors

Inventory Turnover Ratio System

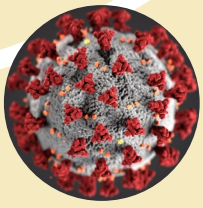
Marketing Assessment of Electric Vehicles

Digital Energy Management

Ripple/Catalytic Effects

Mentoring of Purdue Students

Promoting Information Sharing Among Manufacturers



Tackling the COVID Challenge

Digital Agriculture
Ripple Effects Mapping (REM) Sessions

Two sessions were held with representatives from the agriculture sector in the WHIN region. A subset of participants was directly engaged in agribusiness activities and others were educators associated with the Purdue Cooperative Extension Agriculture and Natural Resources program area. Still others, including WHIN Ag Alliance members or WHIN Tech Partners, completed questionnaires containing the same questions as those posed during the REM sessions. Their insights are captured under three major headings: (1) Building Organizational Capacity; (2) Advancing Digital Agriculture Applications; and (3) the Ripple/Catalytic Effects Resulting from WHIN.

I. Enhancing Organizational Capacity

1. Building a Purdue Extension Team Focused on Digital Agriculture

The introduction to, and adoption of, sensors, drones and other technologies by the agricultural community, was designed to be carried out, in a significant way, by the Purdue University Cooperative Extension system, particularly state specialists and county-based educators associated with Extension's Agriculture and Natural Resources program area in the Wabash Heartland Region. As a result of funding from WHIN, one of the most urgent priorities was to strengthen and expand the capacity of Purdue Extension to deliver technical assistance, educational programs, and other support services to farmers, agribusiness and other related sectors in the region.

One of the first investments made by Purdue Extension was the hiring of a person to serve in a full-time role as the Digital Agriculture Extension Coordinator. WHIN funding also created the opportunity for two additional positions in precision/digital agriculture data science and technology. The REM participants were uniform in stating that the addition of a specialist with expertise in UAV technology and other digital/precision agriculture applications was a key step in supporting Purdue Extension's digital agriculture efforts within the WHIN region and beyond. One participant stated:

> *Purdue's Digital Agriculture Extension Coordinator is just tremendous. The quality of his work, his passion for his work has just been a godsend in terms of making this project successful.*

Under the leadership of this coordinator and other key Purdue College of Agriculture faculty and professional staff, major strides were made in building a strong Extension team that was able to accelerate the adoption of sensors, drones and other new technologies by farmers/agribusinesses. One Wabash Heartland Region Extension Educator noted:

> *WHIN for me has been all about relationship building. I don't think I would have near the relationship I do with the farmers in my county because we get to go out and talk to him quite a bit [about WHIN]. The Digital Ag Extension Coordinator does a really good job of keeping me in the loop on what he is doing, which I really appreciate. My background is in ag education, so I have a teaching license. When I was at Purdue, I learned a lot about a lot of things, but nothing super specific. I have*

a broad knowledge, so being able to get out in the fields and learn from [the Digital Agriculture Extension Coordinator] has been a huge advantage for me in terms of professional development.

The fruits of their collective efforts are highlighted the next section (i.e., Advancing Digital Agriculture Applications) of this report, but one of the digital agriculture REM session participants credited the WHIN initiative for catalyzing them:

> *I would say the connectivity that they brought, so the ability to unify and connect different areas that were part of their initiatives. There were a lot of things going on. The WHIN initiative enabled us to get together and figure out a grant to apply for together -- all the connectivity that was not there in any kind of capacity beforehand. We have Extension, and that's great. But there are certain projects that nobody knew about before WHIN brought all of that together.*

Furthermore, WHIN funds, along with resources provided by Purdue Extension, were used to purchase drones and train a cohort of Extension educators to deliver educational programs to local farmers. Purdue leveraged the initial WHIN grant from Lilly Endowment Inc. (LEI) for a total of $14,619,621 in additional investments in digital agriculture initiatives and innovations. WHIN-Purdue raised $2.75 for every WHIN dollar invested, resulting in a 174.9% return on investment (ROI).

2. Engaging Stakeholders on the Agriculture Advisory Committee

WHIN's formation of an Agriculture Advisory Committee was viewed as an important step in giving voice to key agricultural leaders in the region. For one, the committee was composed of an excellent mix of people who brought different perspectives with respect to future opportunities in the agricultural sector. As one of the REM participants expressed:

> *Early meetings [of the advisory committee] were really trying to understand how we could use WHIN as a catalyst for IoT-type opportunities. The opportunities for grants were really huge because each of us could go back to our different community projects and encourage others to apply, or we could apply ourselves.*

Also, it was noted that the committee reviewed and became more aware of the various agriculture initiatives they were currently underway or being proposed. In doing so, members of the advisory committee were able to help provide access to key people and organizations in the region or assist in forming partnerships with relevant organizations. One REM session participant shared the following:

> *I would say my interaction with WHIN really began when they were traveling around to different counties for each of their monthly meetings -- and wanted to hear about community projects that were going on. I presented some information about our Big Pine Creek Watershed Project*

efforts, and so then I joined and was a part of their Ag Advisory Committee after that. On that Ag Advisory Committee, it was interesting to watch the different people – probably 15 of us -- who joined and the different community ag initiatives they already had going on. They were from all sectors. There were large farmers who were running multiple different businesses, both cattle and cash crops, as well as leaders in different agriculture enterprises. We had representation from ag companies that offer services to farmers, as well.

When asked to share their thoughts on the value of WHIN to the agricultural community, the general feeling of the group is captured in the following statement:

> *. . . their [WHIN's] trust and willingness to invest in us, to try things, to let us determine where the need is, and then support us in meeting those needs. A lot of organizations would be a top-down kind of thing and this was more of a bottom-up. Where can we help? Where can we plug in? What do you need? Then, [WHIN] proceeded to make those connections and make it happen.*

3. Investing in Wabash Heartland Region Farmers through the WHIN Ag Alliance

The WHIN Ag Alliance, launched in 2019, was an opportunity to gain buy-in from the region's farmers, while offering them digital agriculture services from vendors vetted by WHIN. REM session participants mentioned several times the importance of the regional awareness WHIN brought to the Wabash Heartland, specifically stating:

> *. . . just providing a service to help farmers understand this technology, teach them on how to use it, and ultimately, make better input decisions based on this technology has been great.*
>
> *. . . so farmers see this discussion [about digital agriculture] in events or summits or blogs or news, and they don't feel that it's close to them. But, when you have WHIN and its tech partner companies going to visit them to hear what they think, they begin to feel differently about it and consider technology adoption. Then, when WHIN comes back two weeks later and says," Look, do you agree with that? That's what you told me. I disagree with you a little bit on that. That's why I did something different." The farmers begin to feel that they are part of the change and not being replaced and being disrupted. So, this thing I think WHIN does really, really well.*
>
> *We've been doing agriculture more efficiently; we've been producing food and making agriculture better every year, and we have to do it. And I think WHIN is part of that. They are creating this idea that we have to do this, we have to change, and we can be the center of this new digital agriculture – and making them understand that this is something that will not replace them, but will empower them.*
>
> *A lot of these guys have kids that are coming out of the college or coming back to the farm, and so they're going to be the ones that take on this technology and implement it.*

II. Advancing Digital Agriculture Applications

1. Developing UAV/Drone Curriculum & Delivering Training

One of the top priorities for the Purdue Extension digital agriculture team was to produce high-quality curriculum resources focused on the use of UAV/drones on the farm and the process for securing the required credentials for deploying drones on farms. When a draft of the curriculum resources was completed, the Extension team invited agriculture industry representatives to review and critique the training resources. The reviewers offered specific recommendations as to the knowledge areas that needed to be included in the drone-related curriculum. Revisions were subsequently made by the Purdue Extension team.

One of the goals of the training was to help farmers apply and successfully secure their FAA 107 Drone license. There is evidence that this goal is being met in the WHIN region as a result of the training being delivered by Purdue Extension. Since the WHIN launch, 785 certificates have been awarded to regional residents as a result of these curriculum development and training efforts. Now, this curriculum is being offered in other regions across the state. For example, according to a WHIN region county Extension educator:

> *Three or four [farmers] that we work very closely with [now have] drones . . . [have] taken the course and [have] their FAA license. [They] now utilize that technology on their farm.*

Moreover, an industry representative taking part in the REM session indicated that Digital Agriculture Extension Coordinator help showed him how drones could be used with some of the agribusiness' field research plots to map different treatment effects. On the basis of the guidance he provided, the company decided to purchase a drone for research purposes. Another REM participant made the following observation:

> *There's still a lot of questions around what is realistic from some of these UAV technologies . . . I think the Digital Ag Extension Coordinator did a really nice job highlighting some of those different things you can detect and different ways you can use this technology on your farm.*

The general view is that the training and technical assistance being provided by Purdue Extension is moving the needle on the adoption and application of drones by farmers/agribusinesses in the WHIN region, as this REM session participant recounts:

> *I think a lot of it was once they started working with the drones, a number of the educators and the Digital Agriculture Extension Coordinator really connected with each other personally and professionally. What they were hearing from industry was, "We don't have qualified people coming out of high schools that we can hire. They don't have the skillsets that we need." They were pretty specific about certain knowledge areas that they needed those people to have. Based on that, the WHIN-Purdue and WHIN-Ivy Tech teams developed the curriculum to really meet the need that industry had expressed the desire for.*

Since the WHIN launch, 785 certificates have been awarded to regional residents who participated in the UAV Technology Signature Program.

2. Expanding Access to Weather Stations & Wi-Fi Services

A key investment made by WHIN has been the purchase and placement of weather stations at various locations in the region. To date, WHIN monitors 187 weather stations across the region to gather critical temperature, humidity, precipitation and wind information through sensors. The value and impact of these stations has been huge according to the REM participants. One of the WHIN region Purdue Extension educators stated that the placement of the weather station at one of the county schools has opened the door for communications with that agriculture teacher and his students. In addition, local farmers are now relying on the information being provided by the weather station. One Purdue Extension educator recalled a pertinent story:

> *I had a farmer contact me last summer and say, "Hey, I think something's wrong with your weather station." And sure enough, there was debris in the rain bucket, so it wasn't measuring right. There are people who are relying on that information now coming out of those weather stations, and it has opened doors for contacts and relationships.*

A second WHIN investment – the expansion of wi-fi access at various county fairgrounds – proved crucial during the pandemic. This important work was spearheaded by WHIN and the WHIN-Ivy Tech team of WHINterns. Because several families were limited in their ability to attend county fairs during the peak COVID-19 periods, WHIN's decision to help install wi-fi at the fairgrounds was impactful. Here is a sampling of what the REM session participants had to say about this investment:

> *[It was] huge because not only then could we broadcast the fair over the internet so people could see what was going on, but now that is getting utilized for more programs. We [now have] more people [coming] to the fairgrounds to use the facilities because they have good wi-fi.*

> *During the fair, we needed internet and WHIN helped us set that up to get live streaming for our livestock shows as well.*

> *We were able to live stream for the grandparents or people that live states away that never get to see their grandkids or family members actually get to show, so that was exciting.*

> *Because of COVID, we had to cap attendance at the county fair. We had to keep it at 250 below at the time for COVID rules and regulations, and so our attendance hit at a total of 800 with the additional online capability at different points of the day for different speakers. That was our highest attendance level that we were able to track.*

> *Norfolk and Southern rented out our fairgrounds a week ago to do a training, and a lot of it is online and virtual. The only reason that they could do that was because of the connectivity of the internet now. That allowed us to bring in this large group of people and train them...*

3. Deploying Sensors & Drones

One of the first collaborative initiatives between WHIN-Purdue and WHIN-Ivy Tech was soil sensor installation in the 65-acre functioning farm behind the Ivy Tech campus in Tippecanoe County (the center of the WHIN region). Test plots of soybeans, corn and cover crops are grown on this farm.

> *So, they've got sensors in the field, buried underground, and then weather stations as well. And the data from those sensors is getting directed from the field through to the Ivy Tech classroom where they analyze the information.*

One WHIN-Ivy Tech faculty member explained:

> *The weather sensor data is the primary data that I use with my students. For that, we also have the sensor in our lab. So, I can in a course description and we can be talking about it and I'd be like, back in that corner, you see that little thing right there. That's the sensor. And you're using the data that sensor got from that field. That's out my corner. And so, the students can be like, oh, this is this isn't textbook. This is real world stuff.*

The work that WHIN and the WHIN-Purdue team did to inform, educate, and increase the adoption of low-priced sensors by farmers in the region was identified as a "big deal" during one of the REM sessions. The ability to track nitrogen levels was seen as beneficial to efforts to carry out sound conservation practices on the farm. Five farmers are currently engaged in a sensor project in the region thanks to the efforts of the Purdue-WHIN team.

> *WHIN-Purdue's work, out of the Birck Center for Nanotechnology, has continued into a large project that's still going on. The team cheaply produced smart sensors designed to monitor nitrogen and deployed them in the farm fields of participating farmers in the Wabash Heartland Region. They're even now becoming a part of a new project with a new professor and a new department within agronomy, so we have continued learning from them since the spring of 2020.*

A related benefit of the sensors the REM participants identified is the ability to monitor nutrients in the soil and detect when there is a decline in soil fertility. In so doing, farmers have been able make better decisions as to when and how much nitrogen to apply. So, sensors have not only provided an environmental benefit, they have also reduced the cost of inputs used on the farm.

> *Every field agronomist has . . . a drone to be able to help troubleshoot things out in a farmer's field. Before I started [with my company], we did not have drones to my knowledge within the company. I was the first one in our seed treatment group that purchased a drone. I think partly that was*

because I had the WHIN-Purdue Digital Agriculture Extension Coordinator come out, fly some plots, and then show firsthand what we can abstract from that . . .

The WHIN project has allowed the WHIN-Purdue Digital Agriculture Extension Coordinator -- and now other ANR Educators -- to work with farmers around the region on "field projects," whether drone-related or relating to other precision agriculture technologies. In 2021, the WHIN-Purdue agriculture team completed more than 20 such projects in the region; they have already exceeded that number in 2022. One of the exciting new strategies highlighted is the work that has been launched in a county in the region. A test field located near the county fairgrounds was used to seed a cover crop with the use of spray drones. The Purdue Extension team applied aerial rates of different trials and were scheduled to demonstrate this at an upcoming field day. The plan was to show drill, airplane, and UAV applications in this trial. This generated much interest on the part of the farming community. One Extension educator taking part in the REM session stated:

> *Future plans are to look at drones in swarms (in multiples), [thus] being able to apply herbicides, fungicides, seed covers in a timelier manner. New technology is changing and evolving so fast, you just almost don't know what questions to ask. But definitely, people are attending and curious in these areas where we're doing this kind of work.*

4. Attracting a New Firm

A new company that relocated to the WHIN region stated that the WHIN organization played a significant role in attracting his company to the region. Thanks to the help of the WHIN team, the company owner was able to connect with a number of people who could provide advice and guidance to the individual as he was contemplating expanding his business to area. This included how to fine-tune agriculture technology innovations he was deploying in another country to conditions in the WHIN region. More specifically, he offered the following observation:

> *The WHIN team had entrepreneurs and engineers that understand the small things. So, we had to explain every single detail of what we were doing. And after that, they started giving us suggestions and how it could work, and even trying to bring the discussion about how it could connect to other solutions that they [were] working [on].*

III. The Ripple/Catalytic Effects Resulting from WHIN

The efforts by the Purdue Extension WHIN team to develop curriculum modules on Unmanned Aerial Vehicles (UAV) and deliver the program to individuals in the agriculture sector created an unanticipated demand for such training by non-agriculture groups in the region and across the state. We highlight the ripple effects associated with the Purdue UAV efforts in this section of the Digital Agriculture REM report.

1. Adapting the UAV Curriculum for First Responders

The educational products the WHIN-Purdue team created on UAV/drones for the farming sector proved to be of

great interest to first responders. Because of the heavy emphasis on agriculture in the initial set of curriculum products, the WHIN-Purdue team revised the curriculum for use with first responders (i.e., firefighters, law enforcement). One of the Purdue Extension educators noted:

> *We [had] to do some adaptation and [use] different drones.*
>
> *I was approached by the local fire department to do [a UAV] class. We offered the training and we had three firefighters and three city police officers . . . take the certification course because that municipality [now has] a drone. I commend them because they can fly without having a certification [because] they have a waiver . . . but . . . they wanted to do it right. They wanted to understand the regulations . . .. [and how drones] work. [The city] paid the fee to [attend] the course and [they] are now going to be able to do search and rescue and accident scene recreation, and then take that and expand to other districts or other areas.*
>
> *It's been great because . . . one thing you don't even think of, they took one of our little half pound drones and flew it into some other rooms within [a] facility to clear rooms, so what's a little bitty $200 drone to go in and clear a room versus the life of an officer to go in there and personally make sure that there's not a perpetrator in that room is just a great use I hadn't even thought of. Just those continuing compounding things that are evolving from this program just never ceases to amaze me . . . and I think we're just tipping the iceberg on this technology and what we can use it for.*

2. Creating a Digital Agriculture Curriculum for High Schools & Career Centers

One important observation that emerged from the agriculture-focused REM sessions was the concern expressed by agriculture industry leaders that high schools were not graduating students with the requisite skills to qualify for jobs in the agriculture industry. In response to this concern, the WHIN-Ivy Tech and Purdue-WHIN teams each developed digital agriculture curriculum targeted to juniors and seniors in high school and career centers. The curriculum focuses on a variety of key topics, such as soil and plant nutrient management, integrated pest management, precision equipment, and UAV technologies. The WHIN-Ivy Tech curriculum has been approved by the Indiana Department of Education and is being utilized by WHIN region high schools and career centers in Indiana. One WHIN-Ivy Tech faculty member mentioned:

> *[WHIN] has certainly created some networking outside with industry. As we've brought in technology from different companies and from Purdue both, we have been introduced to new people and new organizations that we not only utilized, I guess, related specifically that technology, but who have also presented to our students about that technology and the use of that technology. In some cases, really more in informal ways, they've kind of advised in terms of erection of the program and technology in the ag industry -- and where that's heading and where our program needs to look moving forward.*

One of the digital ag REM session participants mentioned a specific school that benefitted from WHIN's efforts:

> *One of Warren County's schools, Seeger Jr.-Sr. High School, has a precision agriculture program that WHIN really helped launch. There have been some extremely valuable externships that have come from this program. Many area agriculture entities are more closely linked to the school through this program.*

The WHIN-Purdue drone curriculum development was funded by several seed grants, and actually purchased by a career center in Alabama. The proceeds from that sale are offsetting the cost of adapting the curriculum for use within Indiana's 4-H program as a 10-year 4-H project.

> *So, we are basically taking that same career center curriculum and compressing into a year-by-year 4-H project covering many topics within digital agriculture. Each year in 4-H, they're going to dive a little bit deeper into the content. This is all stemming from this initial project. Eventually, this is going to be an interactive computer-based learning type of program.*

In addition to the 4-H curriculum, the hands-on nature of the UAV drone instruction found its way into Purdue's digital agriculture university courses on campus due to WHIN's influence, recalls a Purdue agriculture professor:

> *So, we had Extension working closer with research, working closer with education – all because of the nature of the WHIN collaboration. We started a series of webinars and seminars that bridged the gap between research and extension, as well.*

3. Launching Start-Ups Focused on Digital Ag

WHIN has invested nearly $1.6M into start-up companies focused on digital agriculture. The investments were provided in the form of subsidies for farmers who are adopting their products. Three of those tech partners shared this information about their company's experiences working in the WHIN region:

> *The WHIN project has helped us create new networks both in the traditional 10-county WHIN region and in Knox County through partnership with the Pantheon.*
>
> *Our presence in the WHIN geography and with its Ag Alliance members has helped us see the need for creative solutions to address industry needs, such as our AGMRI Enterprise platform designed for ag retailers and suppliers, and a special partial in-season offering, known as the Disease Detection Solution which is now available.*
>
> *As a travelling agricultural sales professional, I visit farmers across the country to help maximize profitability on post-harvest storage. My biggest challenge—especially being in the reputation-driven agriculture industry—is getting my foot in the door as a credible source to begin a discussion. When the WHIN project introduces us to a farmer, that major hurdle is overcome right away. After*

the introduction is complete, we continue to benefit from WHIN acting as an extra point of contact for our customers in their Ag Alliance to provide feedback or request support. To this day, we have nowhere near the concentration of on-farm business anywhere else in the world as we do in the WHIN 10-county region. We have cited our relationship with WHIN and with customers in the WHIN Ag Alliance during our last rounds of fund-raising. Multiple Ag Alliance members have graciously volunteered to speak with current and potential investors, and this has helped that process considerably.

Another tech partner agreed about the network-enhancing power of WHIN:

> *For us, the WHIN project has helped create a network of growers and ag retailers who have used or been exposed to our product offerings. Additionally, it has helped create opportunities to explore new uses and markets, such as forestry management, for our technology. For example, interest in our technology has been expanded to include researchers at Purdue University and some government agencies. This opportunity has created a foundation for us to prospect with area ag retailers, seed companies, crop consultants and other agricultural suppliers and service providers. I would say between 30-50% of the revenues today were impacted by something that we did directly with WHIN, even though it was something that we learned or something that they introduced us to.*

Yet another attested to the impact of Ag Alliance input on the development of their product:

> *With feedback from the WHIN project, we developed and deployed a set of sensors which use CO2 gas, a leading indicator for potential spoilage events inside grain storage bins, and provide fan operation guidance. This is a significant departure from previous, hardware-intensive solutions for the industry in the past 50+ years, with meaningful consequences for both on-farm and commercial businesses in the grain production and handling space.*

Investments by WHIN into its Tech Partners produced a spillover investment into regional economic impact, as recounted by some Tech Partners:

> *We made in local advertising and promotions, hiring of talent such as account managers and summer "customer success" interns in the WHIN geography, and operational costs for flights initiated from the West Lafayette airport. It also has opened the door to potential Purdue research projects that could leverage flight operations for new uses and data collection in new markets.*
>
> *The partnership with a local ag cooperative has been a very significant initiative that allows sensors to be placed on LP tanks throughout the region to monitor levels and other data. This project alone will be a cost savings, as well as allow data to be used to better serve the customer.*
>
> *Customers in the WHIN region have benefited from the insights and analysis we have provided, resulting in yield protection, better utilization of resources, time savings and a positive return on investment.*

Figure 4. Ripple Effects Mapping - Agriculture Sector Sessions

Primary Effects of the WHIN Initiative

- Building a Purdue Extension Team Focused on Digital Agriculture
- Expanding Access to Weather Stations & Wi-Fi Services
- Engaging Stakeholders on the Agriculture Advisory Committee
- Deploying Sensors and Drones
- Developing a UAV/Drone Curriculum & Delivering Training
- Attracting a New Firm to the Region

Ripple/Catalytic Effects Linked to WHIN

- Adapting the UAV Curriculum for First Responders

- Creating a Digital Agriculture Curriculum for High Schools & Career Centers

Regional Cultivation
Ripple Effects Mapping (REM) Sessions

Two sessions were held with stakeholders of WHIN's Regional Cultivation Fund (RCF). A subset of participants were county local economic development officials (LEDOs) while others were directors of nonprofit organizations who have been the beneficiaries of opportunities to expand their IoT programming to impact the 10-county region through mini-grant awards. Their insights are captured under two major headings: (1) Regional Cultivation Fund Projects Initiated by the Community and (2) the Ripple/Catalytic Effects Resulting from WHIN.

I. Regional Cultivation Fund Projects Initiated by the Community

The Regional Cultivation Fund (RCF) was included as a $10M allocation in the original $39M award from Lilly Endowment Inc. (LEI) to the Wabash Heartland Region. Its purpose was to "fund planning and implementation grants for projects to increase the region's education, vitality and connectivity."

The RCF's framework, outlined in the proposal, included priority points for 1) collaboration between two or more counties, and 2) demonstrating an IoT focus. To encourage nonprofit organizations from the region to apply, WHIN hosted a Proposer's Day in Round 1 and Round 2 (a month before proposals were due) as a matchmaking event for organizations to more easily collaborate on potential projects.

Just over $2M, or 20% of the amount allocated as part of the Regional Cultivation Fund, was awarded to nonprofit organizations in the Wabash Heartland Region during two of the five rounds originally planned. After the first and second WHIN Proposer's Days that launched Rounds 1 and 2 of the funding, WHIN decided to no longer solicit proposals from regional residents but to issue Requests for Proposals (RFPs) for specific initiatives, with focus on such topics as e-learning and rural entrepreneurship. However, the 11 projects (9 organizations) funded by Rounds 1 and 2 have been reporting their impact since 2019 via monthly reports, and the project managers were invited to participate in the two regional WHIN REM sessions to share their outcomes and stories of regional collaboration. These projects were initiated by the community, giving residents a greater stake in their sustainability.

1. Manufacturing Education & Workforce Connection (Education)

The two projects funded under the manufacturing education category were the Tecumseh Area Partnership and the Eleven Fifty Academy.

The Tecumseh Area Partnership (TAP) project received two years of implementation grant funding to expand its K-12 career exploration offerings into all 10 counties of the WHIN region. From computer programming with CoderDojo, to engineering with IN-MaC Design and Innovation Studio, to robotics with Robotics in Manufacturing Camp to advanced manufacturing exposure through Manufacturing Week, TAP has served 607 elementary students, 744 middle school students, and 2,940 high school students in the WHIN region. Three REM session participants who run nonprofits that benefitted from TAP's programming in their county noted:

> *We were able to draw in kids to our summer camps who we don't normally see in our afterschool program at the Boys & Girls Club. Kids were coming from other area county schools to come to robotics camp because it was something that was not offered anywhere near them. So, it was*

programming bringing people in versus having childcare need to fill. When we were able to offer the programming of this cool new, innovative things, people would come for that. I mean, kids didn't have to come to club because their parents were working – their parents were at home. It really sparked that kind of aspect of the club that we didn't really have before.

Definitely, the design innovation studio! Having that opportunity has been something that we can go out to our local manufacturers and say, "What do you want to see from future employees? What do you want them to know?" Even though it's a primarily elementary school population, career information has to start someplace – and the younger the better.

If we can build a foundation in elementary school, then they're not so shocked when they get to middle school and high school that these things exist. And if we start them young, they'll go into those pathways. We should introduce girls to manufacturing and engineering by saying, "Hey, you can build things with your hands. You can do engineering work, and there are cool things out there." And kids want to do what they see, and if they never see a girl who does manufacturing or engineering, they're not going to choose that career pathway. So, we're able to bring that to our small community, those options. Whether they do it or not, at least they can see it and know that it's out there.

Eleven Fifty Academy is a nonprofit, educational institution, providing services to a group of individuals in the community who would like to scale up quickly through a computer coding "boot camp" of part-time classes, lasting only 12 or 14 or 24 weeks. Eleven Fifty works on creating and encouraging lifelong learners, says one of the organization's directors:

> *By nature, the individuals that have a propensity towards coding are the ones that are very curious, and want to keep learning more.*

In terms of markets for revenue, Eleven Fifty Academy says it is less focused on revenue and more on creating an opportunity for helping individuals scale up into careers in technology. That's why they place the focus primarily on community engagement.

> *From a connectivity standpoint, our goal was to create awareness; to learn what type of careers and what type of jobs are available in technology in the area; and then, provide information and knowledge to turn those stories into action items for educating high school students (for example) regarding the opportunities around them in their backyard and also identifying the relative ease with which all of these counties and their economic development organizations can work in collaboration.*

The planning grant that Eleven Fifty Academy was awarded assessed the coding needs of businesses in the WHIN region. It provided funding for Eleven Fifty to have a team of interns from Wabash College, who were instrumental in helping collect data from those local businesses. The results?

> *Based on the research we completed, the [Eleven Fifty] curriculum fits the needs of the population in the Wabash Heartland. Now we're looking for partnerships to make it possible for us to have a school based here.*
>
> *When a trainee goes through our bootcamp, Eleven Fifty provides the community with a professional that is scaling up a career in technology as a software developer or a web developer. That professional's position with a company provides the community with a sustainable job. We've seen through our numerous graduates and alumni that when a professional is earning a living with an average starting annual salary of $55,000, that professional's salary will keep on increasing from there. This adds vitality to a community because that person is earning a wage above the community's average. These professionals in the community are able to do many things, personally and professionally, and also contribute to their community in many ways.*

2. Broadband Infrastructure & Deployment (Connectivity)

The WATCH Communications broadband project was funded under this category. This project was enabled by the North Central Indiana Regional Planning Council (NCIRPC) that brought together the Local Economic Development Officials (LEDOs) from all 10 counties in the WHIN region who each raised a match from their respective counties. The goal was to work together in identifying the county assets that could be used to leverage regional broadband opportunities for planning, infrastructure and digital adoption.

One LEDO commented on the WATCH Communications project:

> *For us in Montgomery County, we were initially talking about doing our own broadband assessment and having a stakeholder group where we would plug into each of our individual communities throughout the county. We knew it was an issue. We knew we needed to address it, but it's about building priorities with available resources, and so it stayed on the back burner until this opportunity came along.*

Another LEDO added:

> *We know that "sensoring" is certainly a very significant part of agribusiness now, in monitoring soil temperature and moisture and seed planting depths. All of those things that are being done right now on combines and planters that are built in technology. Unfortunately, most of the farmers don't have the technology on the farm, as far as broadband and wi-fi connectivity, to be able to upload or download any of that technology. Having the broadband available to utilize the sensors that are being built by John Deere or Holland or any of the other manufacturers will be a game changer for our community.*

In addition, the Wabash Heartland became the first region in the continental United States to host an aerostat. The only other aerostat used to supply aerial broadband was in the U.S. territory of Puerto Rico where it was utilized for disaster recovery. However, WHIN's aerial solution to broadband coverage was a short-lived endeavor, eventually yielding to a more terrestrial-based model. One of the WHINterns worked on the aerostat project and shared her insights during a digital agriculture REM session:

> *I worked mainly on the aerostat project that was like a big blimp out in rural Indiana. We were trying to launch it to collect data from similar sensors out in the fields and then working on bringing broadband to these rural areas. The idea is you have a receiver on the blimp so when it's up in the air, it has a 50-mile radius to collect data from the sensors out in the field. Then, the receiver puts the data up in the cloud so you can access it remotely. I'm studying agricultural engineering with a focus on like machine systems, which is very much like mechanical engineering with an ag focus. So, not knowing anything stuff that flies (because we don't study things that fly in ag engineering), I asked lots of questions. The experience helped me realize that I can do other things – and not to be afraid to jump in. Being involved in the launch, I also learned that projects don't always go like planned or happen on time. We were supposed to launch the aerostat in March and it was July when we finally launched. A lot of people came from Purdue, Ivy Tech and the Indiana state government for the big event. So, my internship was a really different experience than a lot of my fellow classmates who went and worked at companies that did more traditional engineering kind of work. But I'm actually going to work for Caterpillar when I graduate, so I guess it worked out!*

One of the WHIN region's LEDOs added his perspective on the aerostat:

> *Several years ago, we collectively started working on bringing broadband to our underserved areas and each of our counties. And we worked with the WHIN organization to develop a grant, to study where our vertical assets are, where we might be able to put towers as such to improve the service, particularly with our children that had to have e-learning and would not be able to do that from their home. The WHIN organization tried to pilot a new initiative using what they call an aerostat. It's a blimp that's 90 feet long, loaded with antennas and was to be tethered and raised 1500 feet in the air. In the meantime, the WHIN organization took two of our tallest vertical assets which are grain elevators and are placing antennas on the top of that, which will give us the coverage that we need in our townships without broadband. So, we are going to end up getting the coverage – just without the excitement of having a blimp floating in the air. But anyway, it was a good try.*

One of the Local Economic Development Officials (LEDOs) who was involved with several broadband-related WHIN projects, summed it up by saying:

> *I think that the stories that have come from WHIN are varied. Some involve very complicated scientific terminology about broadband solutions, and others seem more simple like weather stations for some of our local farmers. The efforts of WHIN to help schools with broadband solutions were a bit of a pivot but absolutely necessary due to all the shortcomings with broadband that COVID pointed out.*

3. Precision Agriculture & Workforce Connection (Education)

The three projects funded under this category included: a planning grant to support Field Days at Frontier School; a precision agriculture assessment planning grant and a follow-on implementation grant to assist Ivy Tech in understanding the needs of precision agriculture businesses and purchasing related equipment to better instruct students in their degree program; and an implementation grant to purchase drones and help high school students at MSD of Warren County become certified UAV pilots.

One of the grants was awarded to make a virtual Field Day possible. A school superintendent recalls how the investment benefitted his school corporation:

> *We hosted a virtual field day in 2020. It was in the fall and we still had COVID restrictions, so we opened it up to those who could attend in person but socially distanced, but also made it available to those who didn't feel comfortable – or weren't able to – attend in person. WHIN enabled us to make this a very large event, and so we had… national and international attendance from state and federal partners who were not allowed to travel. We couldn't have done the virtual component without WHIN being a part of that. We capped our event for in person attendance to 250, but our total attendance hit 800 with the additional online attendance at different points of the day for different speakers.*

Indiana West Advantage applied for both the precision agriculture planning and implementation grants in partnership with Ivy Tech Community College. One Ivy Tech faculty member said this of the WHIN mini-grants awarded and their regional impact:

> *As a result of the planning grant, we discovered that there was a really, really high local demand by businesses for students who were educated both on the agronomy side and the equipment technology side related to precision ag. And then from there, we used the data that we had collected to apply for an impact grant, which then allowed us to launch the precision ag program here at Ivy Tech, Lafayette, including hiring a full-time faculty precision ag program chair, adding on a maker space/classroom, and then also purchasing some new equipment and technology related to the precision ag curriculum.*
>
> *And then when we added the program, we re-assessed of the classes that were in the precision ag program. We brought people in from industry to review all of that and talked about what was still relevant, what needed change, what needed to be added, etc. Then, as a requirement of graduating from the precision ag equipment technology (PAET) program, students have to complete an internship. So, we are now sending students out to those precision ag businesses that we built a relationship with during the whole planning/implementation grant process. Now, our instructors are going out and visiting the site, following up with the students, talking to their supervisors, all of those types of things.*
>
> *Because we're a statewide institution, we have to confirm that our content is similar across the entire state. So, it's up to the curriculum committee and they have representatives throughout from all 19 Ivy Tech locations, and they come together to discuss curriculum matters three times a year for a day, each time. And we look at different things, creation, maintenance and all that.*

The WHIN project has allowed us [at the three Ivy Tech location in the WHIN region] give real world examples as opportunities for our curriculum committees to incorporate into different courses throughout the state, if they so choose. One real world example we've shared is how we are able to use real-time data from our weather stations and in-field sensors to generate a data dump of raw data that is constantly being updated that students can practice with for data analysis purposes.

MSD of Warren County was awarded an implementation grant to purchase drones and other equipment for their precision agriculture program at the high school. The program's lead teacher explained what this enabled the students to do:

> *Without the grant, we would not be able to purchase the necessary items. Technology is expensive. We were able to utilize the grant money to give our students a hands-on experience with precision agriculture. Also, through the WHIN program we were able to collaborate with Dr. Erickson of Purdue University on the course that he created. That really helped our teachers. We also collaborated with professors at Ivy Tech, and that was great, too!*

Because of the connections made possible by the WHIN funding, MSD of Warren County now has 25 local industry partnerships and a path forward. The lead teacher added:

> *We identified a follow-on grant to pursue, called the Next Level Agreement, and it's through the state of Indiana. We applied for that and were awarded! Also, through the Next Level program of study and the grant received, we agreed to help develop the curriculum for the precision agriculture course. That became available to all schools in the state of Indiana beginning last school year (2021- 2022).*

The most exciting part?

> *We are educating and developing students to directly go back into their own family farms and use precision agriculture technology. Many of the current farmers – mainly, the older generation – hear about this technology, but it can seem a little overwhelming for them. So, we are training the younger generation to go and use that as well as implement the innovations on their family farms. We also help the younger generation when they go to school so that they eventually return home and use their skills for the region's vitality.*

4. Community Beautification & Environmental IoT

The three projects funded under the category of vitality, included: WHIN Walls, the Indiana Recycling Coalition's planning study and trail planning/development through the Wabash River Enhancement Corporation (WREC).

WHIN Walls is a community mural project, embedded with IoT placemaking components, that was awarded to each county through the Tippecanoe Arts Federation (TAF). According to this WHIN regional stakeholder, community partnerships were essential to the completion of their project:

> *So, we hired artists-in-residence to work with community members to paint murals on public buildings in every one of the counties. WHIN granted $5,000 per county, but the murals cost closer to $10,000 to create. So, the counties had to come up with additional monies. In Fountain County, we have Covington, Petersburg and Attica, which tend to operate as three separate communities. When it came time to looking for one location, each one of the three areas wanted a mural. So, the three communities worked together – three to five people from each county – and we worked on the ideas.*
>
> *Partners like the community foundation, the city government, and lots of local residents and businesses stepped up to provide in-kind donations, equipment, and that type of thing. The funding was to go toward improving an eyesore, so there was a lot of examination of the various places that these murals would be located so that they would be in the public eye.*
>
> *Also, Fountain County has been very slow in the development of art appreciation. So, this project helped serve a twofold purpose – beautification and art appreciation. I've been in this county since 1977, and it's probably the most unifying event that I've seen in the 44 years that I've lived here. We had one dedication service in Covington that was attended by people from all over the county.*
>
> *They were really, really interested in art so much that now they want to go forward and address more places that need some beautification with murals. They have some neat ideas as far as I know. I haven't really seen anything in the way of funding for that yet, but it was really a unifying project for those three communities in the county.*

Yet another WHIN Walls participant mentioned:

> *The mural project for our community was implemented through WHIN funds to TAF. The mural project took place over a week's time in our community. Many community members came to our downtown to watch the artwork come to life on the side of a building. Because of this project, I believe our community now has a much higher appreciation of public art and the benefits it brings to communities. Our community is asking where the next mural will be located and how soon we can have another one.*

The Wabash River Enhancement Corporation received both a planning grant and an implementation grant from WHIN in Rounds 1 and 2 of the funding. Their work focused on connecting trails across the 10 counties to connect to the larger Greenway Corridor. One REM participant who worked with this project, commented:

> *I've also worked a little bit with Wabash River Enhancement Corporation (WREC) and others in the more southern part of the WHIN region to help advise on part of the planning process. WREC received a planning grant for the Greenway Corridor trail, and so I've been advising them on matters with landowners and creek routes. The master plan helps us sell the idea locally and fund it regionally.*
>
> *So, it had helped us put that [master plan] together for potentially getting up to $7 million in match towards projects on the Wabash River Greenway. I think it provided the initial scope of work that we could build off of in a relatively short period of time.*

Another REM participant involved with the WREC project from another county, added:

> *I was originally involved in proposing a WHIN project for the Panhandle trail, basically a trailhead regional plan for our downtown to connect. However, there were a bunch of others interested in trails and waterways in the region, so we put together a massive committee to look at how to make this work regionally. We worked on a master plan to show how this impacts us locally and regionally.*
>
> *The biggest "win" for us was with that funding, we were able to get our match to connect to France park, as well as to about a mile of trail north from here to get closer to the community river estate part (our match for the Next Level Connections trail). And we were just notified last week that we did receive the Next Level Connections trail grant!*
>
> *So, without that funding, we would not have been able to make our dream (that we've been working on since I think 2006) a reality.*

The Indiana Recycling Coalition (IRC) was funded by WHIN to study the regional recycling ecosystem. By building working relationships with the leadership in all 10 counties of the Wabash Heartland, IRC hoped to explore a recycling partnership that could include using IoT sensors in the tracking of recycled products throughout the recycling process. One of the organization's leaders commented:

> *We've been benefitted quite a bit from being able to do outreach beyond what we normally would in this region. We have been fortunate just to interact with the people that we met through the events WHIN has hosted.*
>
> *I think we did we did a good job of engaging Purdue students in the process of data collection. Engaging community members and organizations got tricky because of COVID-19.*

She further commented on the work involving IoT sensors and IoT- related projects:

> *Towards the end of the project, we were able to complete the report. But, the finale of the project was challenged in terms of what we intended to do with the report. We struggled to implement the deployment of IoT sensors in the project for data collection. We didn't find a good application for those in our process that made sense to justify the expense of those to gather data. So that was challenging for us.*

What was missing?

> *I think, for our particular project, the policy component was missing. Indiana Recycling Coalition (IRC) feels that recycling is going to have challenges. We're entirely reliant upon economic factors, and policy would be helpful. I think if there was a policy component to WHIN that allowed us to interact with elected officials to drive policy, that would actually support what we're trying to accomplish. That would make it more meaningful for us.*

Next steps?

> *Although my organization is not positioned to do more data collection, we should position ourselves to work more intentionally with partners that are well equipped for data collection. So that in the future, we can use their data, share the data and utilize it to push policy objectives for us.*

II. The Ripple/Catalytic Effects Resulting from WHIN

As was noted in the introduction on Ripple Effects Mapping (REM) process, the value of this qualitative method is that it helps document outcomes that WHIN was seeking to achieve in the region, but also those activities that were not expected or anticipated. These constitute the ripple or catalytic effects associated with WHIN's activities. We highlight three such effects that were captured in the REM session with regional representatives who were recipients of the Regional Cultivation Fund (RCF) funding in rounds 1 or 2 (initiated by WHIN Proposer's Days held in 2018 and 2019).

1. Local Investments

A counterfactual, in the form of the statement "If not for WHIN . . . ," was used during all seven REM sessions to get participants to recall what now exists in the Wabash Heartland region that would not have existed otherwise, if not for the funding infused by Lilly Endowment, Inc. (LEI) and allocated by WHIN, WHIN-Purdue and WHIN-Ivy Tech. Answering from their perspective as resident of two of the 10 counties that benefitted, these participants said:

> *We're a small community. WHIN has been amazing to be able to offer these kinds of cutting-edge technologies that kids can be hands-on with at the elementary level. There's just no place around where we are, so we've just been so blessed that we were picked for that kind of interaction and that kind of experience for our kids. Now, we're able to do so many things, and the sky's the limit for what we can do. And, to think, it all started with the WHIN stickers on Chromebooks for us, so . . .*
>
> *For sure! The people I have met the past 3 years have had a lasting impact on my business, including investments in local advertising and promotions, as well as hiring talent.*

2. Community Collaboration

Several participants in the regional REM sessions cited WHIN as a catalyst for community collaboration. One REM participant shared the following heart-warming story:

> *. . . I think the community working together, it's like, well, when we got ready for the dedication [of our WHIN Walls project], they asked me to make some comments. So, I made up this little cheer that was [about] our county being the WHIN-ner!*

The WHIN Road Shows literally took WHIN's staff "on the road" to three Ivy Tech campuses where regional stakeholders from all 10 counties were asked to bring their ideas, questions and concerns for facilitated community conversations in 2018 and 2021. One WHIN Road Show co-convener and participant had this to say:

> *The Clinton and Carroll County Community Foundations have assisted with coordination of the WHIN Road Shows in their respective counties. This included securing meeting rooms, invitation list development and managing attendance. In particular, we have used this expanded knowledge in the development of the invitation list.*

3. Regional Focus

One outcome of WHIN has been a heightened regional awareness. WHIN's first placemaking survey (conducted by the Purdue Center for Regional Development) asked regional residents if they considered themselves part of the Wabash Heartland Region. An overwhelming 72% responded "yes." These 4,000 responses, gathered at the 10 county fairs and online via local community organizations during the summers of 2018 and 2019, helped take the "community pulse" on the issue of identity.

Throughout the REM process, regional stakeholders mentioned how they now think about their region first rather than just their county, in terms of grantmaking and shared resources.

> *WHIN has opened up opportunities to develop regional relationships with key partners in agriculture, manufacturing, education, connectivity and economic development. We have been encouraged to adopt a regional mentality for improving quality of life for those around us.*

Another of the REM participants mentioned:

> *WHIN has also helped us develop closer relationships with community foundations within the WHIN region. This has been beneficial with the expansion of interest to develop impactful grantmaking within a region – beyond the counties we serve. WHIN has also allowed us to expand our network potential with North Central Health Services. This opens the potential for obtaining grants in support of health services in Clinton and Carroll counties.*

One of the Local Economic Development Officials (LEDOs) from the WHIN Region shared his experience working with the other nine LEDOs who serve in the Wabash Heartland:

> *I think this opportunity with WHIN presented it itself and allowed us to create a network around this conversation. We're not there yet. We have made tons of progress, but what has occurred is we've identified those sites where we can put some of this newer technology, and hopefully then bring capacity and access and higher speeds to some of our rural areas in our counties. I'd say it was the opportunity to look at this [broadband] issue [and other issues] as a region.*

Another of the REM participants summed up the group's thoughts with this succinct statement:

> *The development and ongoing work of WHIN has allowed local communities and their [community] foundations to have access to new resources and partnerships as a region.*

Figure 5. Ripple Effects Mapping - Regional Cultivation Fund Sessions

Primary Effects

Organizational Strategies & Activities

Manufacturing Education & Workforce Connection

Broadband Infrastructure & Deployment

Precision Agriculture & Workforce Connection

Community Beautification & Environmental IoT

Project Activities

Community Murals (WHIN Walls)

Internet Infrastructure (WATCH Communications)

STEM Education (Robotics Camps, CoderDojos & Manufacturing Week)

Precision Agriculture in High Schools

Regional Trail System (Wabash River Enhancement Corporation)

Ripple/Catalytic Effects

Local Investments

Community Collaboration

Regional Focus

10 Key Takeaways

1. Ripple Effects.
Seeking out the unintended effects of the Wabash Heartland Innovation Network (WHIN) initiative is just as important as tracking the effects of those that were intended all along. Ripple Effects Mapping (REM) is a critical process for securing the input and insights of those directly engaged and/or impacted by the multi-pronged WHIN initiative. By embracing a multi-method strategy that includes REM, the Purdue Center for Regional Development (PCRD) was able to better capture the full impact of the WHIN investment by Lilly Endowment, Inc., (LEI) in the 10-county region. REM provides valuable input and feedback to the key architects of the WHIN initiative and offers guidance on what projects and programs have had significant impacts, those that require adjustments in order to realize their full potential, and program/projects that have not be developed or launched but are critical to the future advancement of the region.

2. The Ties that Bind.
Discovering the role of trust between regional players – and how it can make or break the effectiveness of an initiative – was an interesting part of the REM sessions. WHIN certainly built stronger, more expansive ties between industry and higher education institutions in the region, but in different ways than were originally envisioned by the architects of the grant proposal and community members who participated in feedback sessions that eventually led to the WHIN grant award. Social capital is often measured as 'bridging" or "bonding," and REM participants gave expression to both types in different instances during the seven sessions that were conducted. Here are some examples of how trust/social capital was strengthened among entities in the region:

- Amongst manufacturing leaders (bonding)
- Between manufacturers and local government officials/LEDOS (bridging)
- Between manufacturers and Purdue University (bridging)
- Between farmers/agribusinesses and LEDOs (between)
- Amongst Purdue Extension ANR educators and their county constituencies (bonding)
- Amongst advisory committee members in both industry sectors (bonding)
- Between Purdue University and Ivy Tech Community College (bridging)

3. Internet of Things (IoT).
Advancing activities across the region powered by IoT was core to the original purpose of the WHIN initiative and played out as one of its major contributions to economic prosperity in the 10 (Benton, Carroll, Cass, Clinton, Fountain, Montgomery, Pulaski, Tippecanoe, Warren and White) counties. This focus helped accelerate the adoption of innovations by farmers, manufacturers and regional stakeholders.

Accelerating Adoption of New Technologies
Deploying Sensors & Drones

4. Brain Gain.
Connecting students to new technologies and real-world experiences was a "win" for WHIN over the past five years. As a catalyst for innovation, WHIN was also part of the equation that attracted several new start-ups and company expansion, like Solinftec and Saab, to the region.

Offering Students "Real World" Experiences
Attracting a New Firm
Mentoring of Purdue Students
Launching Start-Ups Focused on Digital Ag

5. **N = Network.**
Promoting dialogue amongst professionals in the industry sectors of manufacturing and agriculture has been key to the success of the WHIN initiative thus far. REM Session participants repeatedly mentioned the importance of investments WHIN made in convening and facilitating critical conversations within industries, communities and the region at-large.

- *Strengthening Networks/Promoting Collaboration*
- *Promoting Information Sharing Among Manufacturers*
- *Providing High Quality Facilitation*
- *Engaging Stakeholders on the Agriculture Advisory Committee*

6. **Stand in the Gap.**
Providing technical assistance and vital support to stakeholders came up most frequently during the seven REM session conversations and during key informant interviews. From reducing the industry/academia gap and serving as a "third set of eyes" for industry, to launching a myriad of projects on behalf of local manufacturers and agribusinesses that included tackling the COVID challenge, WHIN stepped up to help out when the going got tough.

- *Reducing the Industry/Academia Gap*
- *Tackling the COVID Challenge*
- *Serving as a Third Set of Eyes*
- *Investing in Wabash Heartland Region Farmers through the WHIN Ag Alliance*
- *Launching Projects Tailored to Local Manufacturers*

7. **Shore Up.**
Building capacity within higher education institutions helped the region leap forward. Due to the WHIN funding, the partner institutions (Purdue University and Ivy Tech Community College) and partner organizations (WHIN) had resources to devote to IoT-related initiatives and the people that make them possible. From the Indiana Manufacturing Institute and Ivy Tech Manufacturing Lab to Purdue Extension and Ivy Tech's sensored farm plot, these investments will pay dividends for years to come in the Wabash Heartland.

- *Reducing the Industry/Academia Gap*
- *Building a Purdue Extension Team Focused on Digital Agriculture*

8. **Knowledge is Power.**
Creating new educational products and outreach programs has been a primary benefit of the WHIN initiative. The high school curriculum, college degree courses, industry certifications and digital applications developed by WHIN has transformed the lives and livelihoods of thousands of youths and adults in the 10-county region during the past five years.

- *Developing UAV/Drone Curriculum & Delivering Training*
- *Adapting the UAV Curriculum for First Responders*
- *Expanding Access to Weather Stations & Wi-Fi Services*
- *Creating a Digital Agriculture Curriculum for High Schools & Career Centers*

9. **WHIN-ners.**
Supporting community-led priorities was a strength of the WHIN initiative and a popular sentiment among REM session participants and key informants. Several of them said that without the Regional Cultivation Fund investments, locally driven projects would not have been successful.

- *Manufacturing Education & Workforce Connection (Education)*
- *Community Beautification & Environmental IoT*
- *Precision Agriculture & Workforce Connection (Education)*
- *Local Investments*

10. All for One.

Building a regional mindset was essential to achieving the goals set forth in the WHIN initiative. The extent to which that was accomplished is difficult to measure, but several session participants and key informants commented on this aspect of the WHIN initiative throughout the REM process.

- *Broadband Infrastructure & Deployment (Connectivity)*
- *Regional Focus*
- *Community Collaboration*

[i] Bonding social capital is within a group or community whereas bridging social capital is between social groups, social class, race, religion or other important sociodemographic or socioeconomic characteristics (https://www.socialcapitalresearch.com/difference-bonding-bridging-social-capital/#:~:text=Bonding%20social%20capital%20is%20within,important%20sociodemographic%20or%20socioeconomic%20characteristics)

Appendix

Appendix A. WHIN Question Handout

Mapping the Ripple Effects of Wabash Heartland Innovation Network

To appreciate is the art of recognizing the best in people and organizations – their past and present strengths and potential.

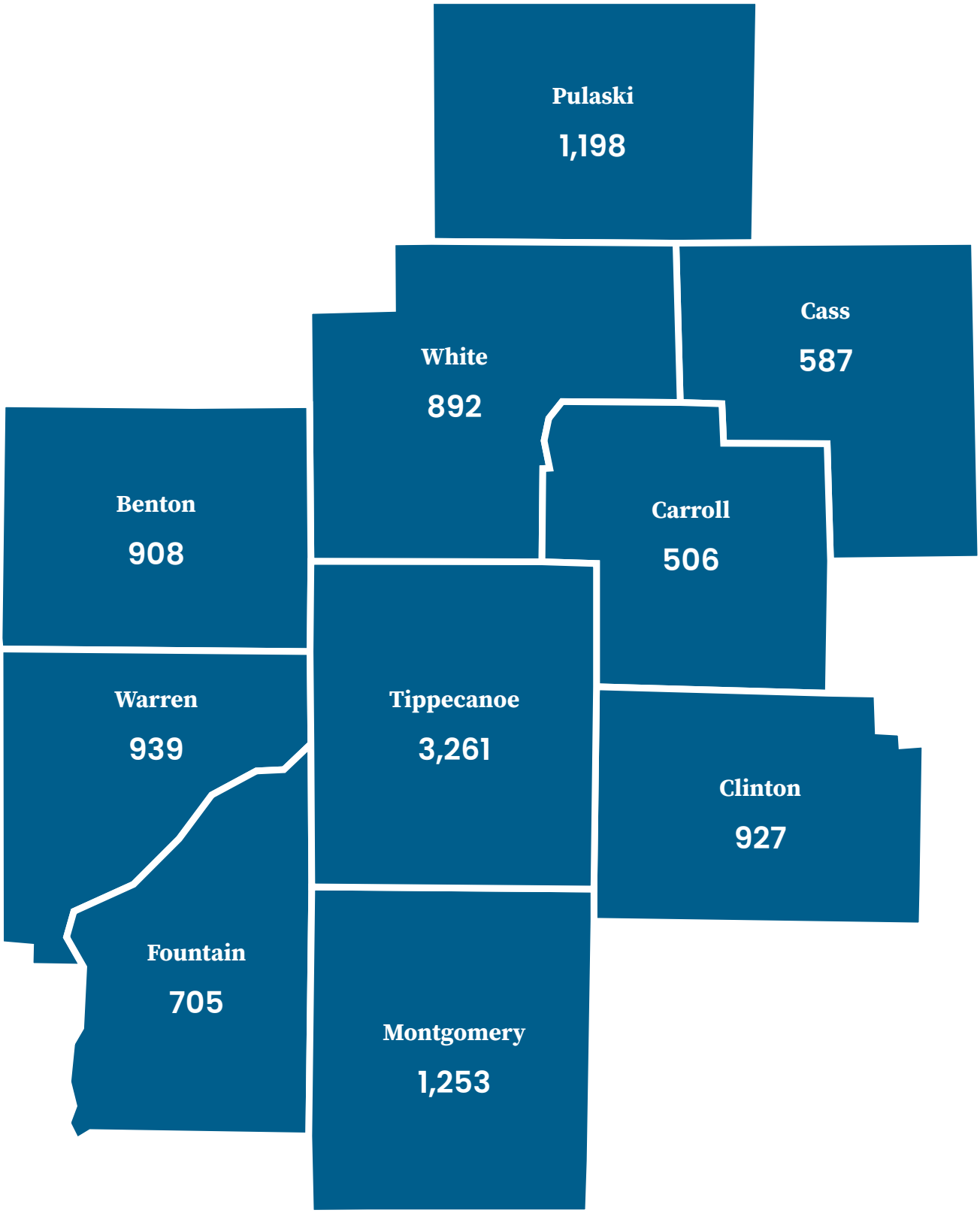
Guiding Questions

1. **Have networks been created or expanded as a result of the WHIN project?**
2. **What new initiatives been developed as a result of the WHIN project?**
3. **Has the WHIN project sparked innovative solutions to industry challenges?**
4. **Tell a story that illustrates how the WHIN project has benefitted your organization, local communities, or your region.**
5. **Have any spin-off interactions or investments occurred as an indirect effect of the WHIN project?**

Appendix B. WHIN REM Session Chart

Day	Date	Time	# of Participants	REM Session Group
Thursday	Feb 24	10am – Noon	3	Manufacturing Education
Friday	Feb 25	10am – Noon	5	Manufacturing Technology
			5	Manufacturing (Key Informants)
Tuesday	Mar 15	10am – Noon	5	Digital Agriculture – Extension & Farmers
Friday	Mar 25	Noon – 2pm	2	Digital Agriculture – WHIN Tech Partners
			2	Digital Agriculture (Key Informants)
Friday	Apr 22	Noon – 2pm	13	WHIN – Purdue Faculty & Staff
			1	WHIN – Purdue Faculty & Staff (Key Informants)
Tuesday	Apr 26	10am – Noon	8	Regional Cultivation Fund Recipients & Stakeholders/LEDOs
			13	Regional Cultivation Fund (Key Informants)
Tuesday	Apr 26	1pm – 3pm	5	WHIN – Ivy Tech Faculty & Staff
			N = 62	

Appendix C. Engagement by County*

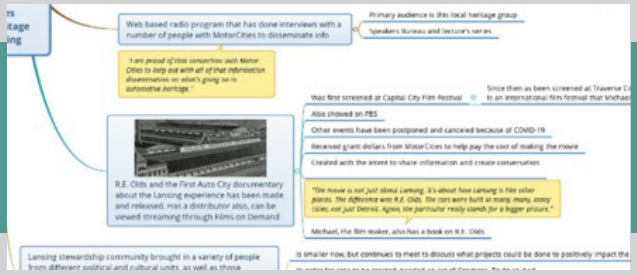


* These are the individual county engagement numbers accomplished by the entire WHIN-Purdue team as of June 30, 2022. The Purdue-WHIN team, (manufacturing, Ag, IoT, and adminstration) has documented over 11,000 regional engagements since the on-set of the WHIN grant.

Appendix D. WHIN REM Invitation

Ripple Effects Mapping to Capture Impacts of the

WHIN
WABASH HEARTLAND INNOVATION NETWORK



Ripple Effects Mapping

Capturing the stories of impact in your programs.

In partnership with the Purdue Center for Regional Development (PCRD) and REM Studios, you are invited to participate in an engaging and innovative evaluation process called Ripple Effects Mapping (REM).

Facilitators:

Lorie Higgins

Debra Hansen

REMstudio.org

The mapping session will take place via Zoom
If you would like to participate, please RSVP to Melinda at mgrismer@purdue.edu

Purpose of Ripple Effects Mapping

The impact of community-focused work is notoriously difficult to measure. Community focused programs may have immediate and direct benefits, but they may also have related indirect benefits beyond initial steps taken. Work done by organizations like WHIN may have ripples of impacts that change culture, policy and people's lives in sometimes unanticipated ways. Ripple Effects Mapping is a way to capture all the intended and unintended benefits of programs while harvesting rich, detailed stories that illustrate those benefits. It's time to imagine: If not for WHIN...