Workshop Summary Report

Date: May 14, 2025
Location: Purdue University
Prepared by: ManuFuture Today Organizing Team

Version: 3.0

ManuFuture Workshop Summary

May 14, 2025

Executive Summary

The ManuFuture Today Workshop, held on May 14, 2025, at Purdue University, brought together 31 industry professionals, a dozen academics, support organizations, solution providers, and 6 other regional partners. The event focused on productivity, equipment health, and the introduction of the Open Access Knowledge (O.A.K.) Platform. Key outcomes included the latest factory floor implementation updates from Terra Drive Systems, Mursix, and REA Magnet Wire. Preliminary O.A.K. platform solutions were shared by Purdue, TMF, and Kirby Risk. These include open-source equipment monitoring, visualization and factory communication tools. Finally, two challenge-based cohort workstreams were introduced to increase manufacturers' participation. This report summarizes the workshop's achievements, participant contributions, and the next steps.

Workshop Objectives

- Manufacturers share progress on implementing solutions to improve productivity, equipment health, and quality prediction. The cohort topics were identified in previous ManuFuture meeting as common challenges among SMEs.
- Introduce and explore the Open Access Knowledge Platform for collaborative technology solutions.

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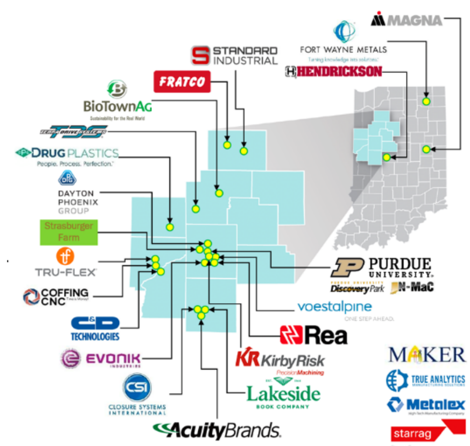
- Identify challenges and network assets through breakout sessions to form actionable cohort workstreams.
- Capture participant insights, strengths, challenges, and proposed solutions to enrich the ManuFuture community.

ManuFuture Today Overview

Manufacturing is the backbone of Indiana's economy, driving over 27% of the state's total output and providing jobs for nearly 17% of its workforce. However, in an era defined by artificial intelligence and rapid technological advancement, small and medium-sized manufacturers face significant challenges in innovating and staying competitive. These companies, which form the heart of our regional economies, often lack the resources and expertise to adopt new technologies effectively. Recognizing this critical need, Purdue University has established ManuFuture Today, a pioneering initiative that fosters collaborative learning networks to empower these manufacturers on their digital transformation journey



ManuFuture has completed over 70 projects with 30 manufacturers since 2018. Digital transformation is a journey integrating technology, people, and business processes.

ManuFuture operates as a neutral platform, facilitating knowledge exchange among manufacturers. Currently 13 companies collaborate across 17 projects in four cohorts: continuous manufacturing, discrete manufacturing, imaging, and motors/compressors. These projects leverage low-cost, open-source sensors for real-time dashboards, addressing challenges like visibility and downtime. The goal is to expand this network through events like this meeting, where small group discussions and knowledge sharing lead to new collaborations and joint initiatives.

Table 1: ManuFuture Projects Summary

Company	Project Description	Process
Rea Magnet Wire	1. Root cause analysis 2. Predictive failure/ monitoring	1. Wire coating 2. Furnace
Fort Wayne Metals	Predictive failure /monitoring	Furnace
Terra Drive Systems	1. Productivity monitoring, MTConnect 2. Remaining Useful Life (RUL) 3. Health monitor	1. CNC -Makino A81 2. Plasma cutter 3. Air compressor
Dayton Phoenix	Real-time monitoring/ anomaly	Seam welder
Kirby Risk PM	Productivity: part fingerprint/ scrap	1. CNC-Okuma MB4000 2. CNC -Mazak 6003
TMF Center	1. Productivity: part fingerprint/ scrap 2. Operation mapping	1. CNC machine tools 2. Work procedure
Hendrickson	Productivity monitoring/ anomaly	Robot ARC welder
Mursix	Productivity monitoring/ energy saving	Stamping machine
Primient	Predictive quality: Crystal	Microscope images
Evonik	Failure prediction	Agitator
Fratco	Predictive maintenance	Injection molding (gearbox)
Acuity Lighting	Predictive maintenance	Scrubber system & Fan
Lakeside Book	Predictive maintenance	Air Compressor

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ManuFuture Today Engagement – Participant's Experience

Workshop participants were asked to share their experience in ManuFuture. The table below summarizes some their responses.

Table 2: ManuFuture Today Engagement Summary Table

Question	Key Themes	Details
1. Participation in Initiatives	Manufacturers participation (ranging from first time to 5 years)	- First-time participants (4); some in early discussions or hearing of ManuFuture Today, engaged in student projects/ cohorts (IFM, MT connect, compressed air, part fingerprinting, productivity/down time), hands-on hardware in the field, 1-2 employees at the meeting, define cohort direction, attended IMI events since 2020, Saturday calls.
	Other participants	- partner organizations (NEO, MassTech, PNW -CIVS, En Focus - South Bend, GE -Kentucky), Governor's and senator Young's office, Ivy Tech, Conexus, 16Tech, WHIN, System Integrator
3. Contributions to Members	Data & Expertise Sharing	- Supplied large datasets to Purdue students; shared IIoT (ISA95 levels 2-4), plant reliability tools, lean principles, CNC templates. KRAM offers digital comm tool; PLC/HMI for monitoring. Worked with FCA on LLMs for knowledge.
4. New Knowledge Acquired	Technology & Models	- Awareness of prototype projects, pulling VFD process data, ML data models, AI for training/education challenges, inspired by Dave Roberst's comm system. - Understanding emerging tech, i4.0 development; learned KPIs, real stories of overcoming shared challenges, digital maturity rethink - network connectors for manufacturers, solution providers;
5. Quantifiable Benefits	Engagement & Collaboration	- Utilized Purdue students for 3 projects; increased company engagement in digital transformation, improved facility comms. - Exposure to others' challenges, similarities noted; - collaboration with ManuFuture to transform work at TMF; outputs not yet clear.
6. Future Support & Recommendations	Technical Solutions	- Advanced analytics on machine data, robotics, vision, AI, predictive vibration monitoring, equipment condition tools/software.
	Academic & Open Collaboration	- Student projects, interns for IT/R&D, Open Access Knowledge with Eunseob, grow to Michiana. - Continued events, peer-to-peer sharing, research database (AI focus); link to resources for "metal-mind" manufacturers.
	Strategic Emphasis	- Ali to highlight AI commons value early, use projects as proof points with specific returns; more networking.

Progress Updates

Participants from Terra Drive Systems (TDS), Mursix, and REA Magnet Wire shared updates on their initiatives.

Terra Drive Systems (TDS), Ben Harpenau

Ben Harpenau, from Terra Drive Systems, presented an update on their digital transformation journey, focusing on sensor deployment to enhance predictive maintenance and operational efficiency. The presentation outlined initiatives started nine months prior, emphasizing a pilot project on a single horizontal machine center equipped with an extensive sensor package to collect data on vibration, temperature, sound, coolant flow, and concentricity. The goal was to oversensor the machine to identify which data points were most useful for decision-making, then replicate effective sensors across other assets

Key outcomes included:

- *OEE Tracking Dashboard*: A dashboard displayed real-time machine status, cycle tracking, and productivity metrics, enabling operator and machine performance monitoring
- *Vibration Detection*: Sensors identified increased spindle vibration on days when the machine was overstressed, allowing troubleshooting, though predictive capabilities were still in development
- *Maintenance Insights*: A compressor sensor revealed a loose mount bolt, leading to a catastrophic failure, highlighting the need for accurate baseline thresholds
- *Coolant Management*: Transitioned from calendar-based coolant changes to concentricity-based changes, improving efficiency based on actual usage

Since the December meeting, Terra Drive Systems progressed by integrating sensor data into daily operations, establishing thresholds, and deploying sensors to other horizontal machine centers, excluding less useful flow sensors. The focus shifted to real-time feedback loops and predictive analytics, with dashboards shared with operators to align performance goals. Harpenau emphasized the cultural shift required to utilize new data effectively, noting that long-standing operations need time to adapt.

Participant Feedback:

Effectiveness of the presentation: - Avg. 7.9 from 12 responses, range 5-10, moderate to strong confidence.

Comments: Alert process unclear; quantify benefits, costs; past challenges, collaboration; good OEE focus, needs context.

Mursix Corporation, Joe Barr

Joe Barr, from Mursix Corporation, presented an update on their digital transformation efforts, focusing on integrating Industry 4.0 technologies into stamping operations. The presentation detailed a Purdue collaboration that equipped a legacy stamping machine with sensors and a PLC add-on to monitor energy consumption, stroke rates, and operational status via a Grafana dashboard. A parallel "smart chute" project was introduced to auto-divert non-conforming parts, track downtime, and monitor press speed and material feed using PLC and HMI, costing $2,700 per unit. The initiatives aimed to enhance efficiency and quality control on older equipment, despite challenges like limited technical resources and scalability constraints.

Key outcomes included:

- *Energy Monitoring*: Sensors tracked stroke rates and energy use, exploring idle-time reductions. Concerns persisted about restarting 1980s–1990s machines.
- *Smart Chute System*: Automated diversion of faulty parts, real-time tracking of good/bad parts, downtime, and press speed, with HMI displays for operators and supervisors.
- *Cost-Effective Scalability*: Planned deployment of 20 smart chute units, limited by a single-person controls department and high machine replacement costs ($2–3 million).
- *Data Visualization*: Grafana dashboards provided insights into operational metrics, though actionable data interpretation remained a challenge.

Since the last meeting, Mursix advanced by implementing the smart chute concept and refining sensor integration on the pilot machine. The focus was on affordable solutions for legacy equipment, with ongoing efforts to scale across 40–50 stamping machines and improve data-driven decision-making. Barr highlighted the cultural and resource barriers to adopting new technologies in a small manufacturing setting.

Presentation Comments:

- Great start; explore automating quality, consider historian database for data analysis.

- Sensor placement hurdles? Rebates for energy savings? Assess short/mid/long-term tech value.

- Plex familiarity, project mgmt templates, and contacts with experienced manufacturers.

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REA Magnet Wire, Dennis Rausch

Dennis Rausch's Update Presentation on Rea Magnet Wire

Dennis Rausch from Rea Magnet Wire presented an update on their digital transformation efforts during the Manufacturing Innovation Network Meeting. Rea, an Indiana-based company with five North American facilities, specializes in continuous flow manufacturing of magnet wire used in automotive and industrial applications. The presentation focused on leveraging seven years of real-time sensor and PLC data to improve process reliability and quality at their Lafayette facility. Rausch highlighted two Purdue University collaborative projects:

- **Quality Prediction Analytics**: Using data models (logistic regression, random forest, SVM) to correlate input variables (e.g., oven inlet temperature) with product quality outcomes, identifying environmental factors affecting performance.
- **Predictive Maintenance for Heating Elements**: Installing current transformers and vibration sensors to detect heating element failures early, reducing maintenance costs and downtime.

Key outcomes included discovering unexpected correlations (e.g., inlet temperature impact) and early failure detection, with plans to scale insights across facilities. Rausch noted growing internal interest from operational excellence and process engineering teams, signaling broader adoption potential.

Participant Feedback:

- Use of ML in Processes: - 5 yes, 23 no or no response; limited adoption of ML in manufacturing.

- Lessons from ML Use: - Useful for RCM, OEE; data only as good as UI; small datasets hinder progress.

- Where to start, how to do it simply without data skills; hardest buy-in challenges.

- Infrastructure for broad deployment; 3rd party vs. in-house; lower-cost sensors needed.

Introduction of Open Access Knowledge Platform

Open Access Knowledge (OAK) is a framework to democratize digital transformation for small and medium-sized manufacturers by sharing low-cost, open-source (non-proprietary) technological solutions within the ManuFuture Network. OAK addresses the high-cost barrier to adopting advanced manufacturing technologies by providing affordable sensor and data pipeline solutions, promoting a "do-it-yourself" (DIY) approach. This empowers manufacturers to build internal capabilities through customizable hardware (e.g., wireless vibration, temperature, vision sensors, Arduino units) and software (e.g., open-source data pipelines, database schemas, web-based dashboards).

OAK fosters a community-driven model, leveraging peer support for continuous improvement and knowledge exchange. An example project was completed with TMF, where detailed project guidelines are shared via GitHub, serving as an instructional manual for technology adoption. Compared to commercial platforms like IFM or Machine Metrics, OAK offers one-time costs, flexibility, and privacy-preserving data sharing with Purdue researchers.

Ongoing projects include part fingerprinting for anomaly detection and low-cost rotating equipment monitoring using spectral analysis, with potential AI integration. OAK aims to create integrated, real-time data pipelines adaptable to a variety of manufacturing context that ultimately reduce adoption barriers and enhance operational efficiency through collaboration and accessibility.

Purdue University, Eunseob Kim

Eunseob Kim, a PhD candidate in mechanical engineering at Purdue, presented the Open Access Knowledge (OAK) concept, emphasizing its role in facilitating digital transformation for small and medium-sized manufacturers. The core idea is to share pilot project details openly within the Manufacturing Innovation Network, enabling other companies to adopt and adapt these technologies.

Key points include:

- **Cost Reduction and DIY Approach:** OAK addresses the primary barrier of high costs by providing low-cost sensor and data pipeline solutions. It promotes a "do-it-yourself" (DIY) model, allowing manufacturers to build internal capabilities by understanding data transformation principles and customizing solutions.
- **Community-Driven Support:** The initiative leverages the network's collaborative environment for peer-driven improvement and support, fostering knowledge sharing among manufacturers.
- **Resources Provided:** OAK includes hardware (e.g., wireless vibration, temperature, vision sensors, Arduino micro-computing units), software (open-source data pipelines, database schemas, web-based dashboards), and detailed project guidelines available on GitHub. An example GitHub page for a TMF Center collaboration project was highlighted, serving as an instructional manual for technology adoption.

- **Comparison with Commercial Solutions:** Eunseob compared OAK to commercial platforms like IFM, Machine Metrics, and Amper, noting OAK's advantages in one-time hardware/software costs, customizable capabilities, and privacy-preserving data sharing with Purdue researchers. Unlike subscription-based commercial solutions ($100–$200/month per tool), OAK allows flexibility and hybrid integration (e.g., using IFM sensors with OAK pipelines).
- **Ongoing Projects:** Examples include part fingerprinting for discrete manufacturing (identifying unique operational signatures via sensor data) and low-cost rotating equipment monitoring using spectral analysis, with potential AI model integration.
- **Higher-Level Goals:** OAK aims to create integrated, real-time data pipelines with multi-sensor analysis and anomaly detection, adaptable to both local and cloud servers, and tailored to discrete or continuous manufacturing processes.

The presentation underscored OAK's potential to democratize advanced manufacturing technologies through affordability, accessibility, and collaboration.

Table 3: O.A.K. Platform Strengths and Challenges Summary

Strengths		Challenges	
Theme	**Description**	**Theme**	**Description**
Cost-Effectiveness and Low Barrier to Entry	Affordable, open-source platform enabling SMBs to adopt advanced technologies.	Limited Support and Maintenance	Lacks robust support, relying on community assistance, complicating maintenance. => need option for commercial service and products (e.g., Linux on google products)
Accessibility and Openness	Open-source structure provides easy access to data, tools, and shared knowledge.	Technical Complexity and Integration	Requires significant expertise for implementation and system integration.
Flexibility and Customization	Adaptable solutions tailored to diverse manufacturing processes.	Data Security and Privacy Concerns	Open-source nature raises cybersecurity and intellectual property risks. => Resolved in other open-source applications via Linux Foundation
Support for Prototyping and Learning	Facilitates low-risk prototyping and learning from shared projects.	Scalability and Applicability	Difficult to scale across large operations or for less digitally mature firms.
Community-Driven Knowledge Sharing	Promotes peer-to-peer collaboration and collective expertise exchange.	Internal Capacity and Cultural Barriers	Limited resources and resistance to data-driven processes hinder adoption.

TMF, Zach Van Meter

Zach Van Meter, representing TMF Center, delivered a presentation detailing his four-year journey implementing low-cost IoT solutions to enhance manufacturing operations, emphasizing practical, actionable outcomes over complex technology. Key points include:

- *Starting Point and Motivation*: Four years ago, Zach attended his first ManuFuture meeting, unfamiliar with concepts like OEE (Overall Equipment Effectiveness). Inspired by presentations, he sought real-time metrics to drive decision-making, moving beyond reliance on MES software or gut-based decisions.

- *Initial IoT Implementation*: TMF adopted low-cost IoT devices, starting with a single amperage sensor measuring data every five seconds. This provided basic visibility into production issues, such as a 10-minute delay after a 30-minute lunch break, which was previously undetected.

- *Part Fingerprinting*: TMF progressed to identifying unique part signatures using sensor data, distinguishing normal from anomalous production cycles. This allowed detection of non-conforming components, though real-time alerts were not yet implemented.

- *Tool Breakage Detection*: A significant focus was detecting tool breakages in CNC machines using amperage data. Zach described identifying anomalies programmatically, enabling potential intervention before damage occurred, a capability not offered by commercial solutions like MachineMetrics or Amper.

- *Data Management*: Data is stored on a local machine and Amazon Cloud, visualized via a Grafana dashboard. Additional sensors and manual annotations (e.g., downtime reasons) were integrated to enhance insights.

- *Open Access Philosophy*: TMF's solutions were developed in collaboration with Purdue's Eunseob Kim, aligning with the Open Access Knowledge (OAK) concept. This approach avoids high-cost commercial subscriptions ($180,000/year for MachineMetrics) and enables scalable, customizable deployment across 150 machines.

- *Impact and Future*: The journey transformed TMF's operations, reducing reliance on operator intuition and enabling proactive issue resolution. Zach emphasized that OAK allows other manufacturers to bypass TMF's three-year development process by adopting these solutions directly.

The presentation highlighted a practical, iterative approach to digital transformation, leveraging low-cost, open-access technology to address real-world manufacturing challenges.

Table 4: Summary of participant feedback for Zach, TMF

Question	Key Themes	Insights
1. Strengths of TMF Approach	Cost-Effective Innovation	- Low-cost, custom, DIY solutions automate dull tasks and scale effectively.
	Action & Leadership	- Focus on key metrics, "fail forward" mentality, and Zach's leadership tie OEE to $/hr for ROI.
2. Challenges of TMF Approach	Real-Time Action & Results	- Hard to act on red flags, react in real time; results unclear, sharing welcomed.
	Development & Maturity	- Years of DIY work, engineering heavy; data too advanced for less mature firms.
3. Offerings to Strengthen TMF	Expertise & Support	- Project management, implementation knowledge; share similar problem approaches.
	Data & UI Improvement	- Enhance UI for context; explore other ways to use data.
4. Additional Comments	Praise & Solutions	- Great work, Zach! Edge AI for real-time; data monitoring is new "machine tending."
	Emerging Ideas & Questions	- Part fingerprinting resonates; how was ROI approximated before starting?

Dave Roberts, Kirby Risk

Dave Roberts, representing Kirby Risk, presented a low-cost digital communication solution designed to reduce operator downtime and improve operational efficiency in their manufacturing facility. Key points include:

- *Background and Initial Approach*: Kirby Risk initially adopted MachineMetrics, a high-end solution that delivered a rapid ROI (less than 30 days) through significant utilization improvements. However, recognizing that such solutions are not universally affordable, Dave explored a more accessible alternative.
- *Low-Cost Solution Development:* Using make.com (an integration service costing $250–$300/year) and Trello, Dave developed a communication system for approximately $500–$600. Operators use tablets at workstations to request support (e.g., maintenance, quality, inspection), triggering notifications via email, text, or shop floor displays.
- *Impact on Operator Efficiency:* Prior to implementation, operators traveled an average of 62 miles per year (370 hours of lost time) to find support staff, often doubling due to incidental conversations. The new system reduced response times from 45 minutes to 10 minutes, significantly cutting wasted time.
- *Cultural Adaptation:* Adopting the system required a cultural shift, taking a couple of months for operators to adjust to using the "walkie-talkie" style communication instead of leaving their stations.

- *Data Logging and Analytics*: Requests and resolutions are automatically logged in Google Sheets, tracking time-to-resolution for each support request. This allows Kirby Risk to monitor and optimize support processes, focusing on resolution speed rather than traditional downtime metrics.
- *Specific Example:* For material handling, scatter plot analysis identified peak request times (shift start and mid-afternoon), enabling targeted resource allocation. This reduced material request resolution time from 51 minutes to 15 minutes.
- *Visualization:* The system integrates with 85-inch Kanban boards across the 24,000-square-foot shop, rotating through support function statuses (material, maintenance, inspection) every six seconds, providing real-time visibility into shop operations.
- *Scalability and Accessibility:* Developed in just two days, the solution is freely shareable, with Dave offering it to interested manufacturers. It leverages webhooks for flexible integration and supports further analytics via Google Sheets.

The presentation emphasized a practical, low-cost approach to improving communication and reducing downtime, tailored for small to medium-sized manufacturers with limited budgets.

Table 5: Kirby Risk Communication & Efficiency Feedback Summary

Question	Key Themes	Insights
1. Real Time vs. After the Fact	Communication Timing	- 12 responses, 17 no response; 33% real time, 69% after the fact; mixes radio calls, work orders.
2. Measuring Wasted Time	Current Metrics	- Operation Rate, Grand Strokes/min, machine up/down (5 min), downtime, idle, changeover time.
	Potential Measures	- Track miles walked, $ via shop rate, utilization, proximity, wait time; hours wasted daily.
3. Effectiveness of Communication	Ranking Overview	- 1 A, 1 B, 5 C, 5 D, 2 F (E as F); varied perception, leaning toward average to poor.
4. Tech Solution for Communication	Improved Tools & Visibility	- Beats andon ropes; off pen/paper; same real-time info for all, shift notes, notifications.
	Feedback & Requests	- Operator story, site visit? Pareto issues, cut waste; Google Sheets not ideal; highly applicable.
5. Deployment Challenge	Rating & Barriers	- Avg. 5.6, range 2-8; moderate challenge due to station count, extra UI; some see it as easy.

Challenge-Based Cohort Breakouts

Challenge-based cohorts are a structured, action-oriented approach within ManuFuture to address manufacturers' specific challenges collaboratively. Challenge-based cohorts follow a rigorous process:

1) **Identify meaningful business challenges** – Meaningful challenges are specific, real-world issues faced by manufacturers that require practical solutions. Six guidelines frame these challenges: they should be among the company's most important, require new approaches, create competitive advantages, involve multiple contributors, differ from business-as-usual, and be timely.
2) **Map network assets** – assets are network resources like technology solutions like technology solutions (e.g., machine monitoring, communication systems), people (e.g., quality staff, reliability technicians), and external programs (e.g., manufacturing readiness grants) that support challenge-based cohorts to address manufacturer's specific challenges.
3) **Develop actionable pathways** – three pathways define how manufacturers can drive practical solutions from within the ManuFuture network – peer cohorts support participants from different companies to solve shared problems, the Open Access Knowledge concept focuses on development and deployment of technology solutions, and student projects leverage university-based student resources to address company challenges.
4) **Identify and launch projects** – projects are developed to address challenges by leveraging network assets within one or more of the defined pathways.

Breakout sessions were organized to demonstrate the cohort process within two themes: productivity and equipment health. Each group identified challenges, assets, and projects. These are listed in detail in the appendix of this report. Below is a list of projects identified in the breakout and summarized for clarity.

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Productivity Breakout

Table 6: **Meaningful Challenges**: Productivity Group

Category	Key Challenges	Details
Inventory Management	Manual Processes & Visibility	- Heavy reliance on manual counts due to poor inputs, lack of visibility (e.g., steel coil inventory, in-process steel).
	Data & Connectivity	- Bad data needs manual verification; 2-3 month lead time to connect PLCs across processes for better tracking.
Manpower & Workforce	Resource Constraints	- Doing more with less manpower; staffing issues burden maintenance and monitoring systems.
	Training & Efficiency	- Lack of cross-trained operators (e.g., machining dept.); education gap on solutions; training for high-efficiency workforce (OEE, time to resolution).
	Employee Performance	- Use data to motivate, empower employees in labor-first market; waiting for support staff and issue resolution delays productivity.
Equipment & Operations	Scale & Maintenance	- Thousands of pieces of equipment; 500 OEE sensors per plant (3rd party monitored); predict downtime, prescribe fixes via improved monitoring.
	Productivity & Changeovers	- Lack of visibility into setup, changeover, materials, people, maintenance; plantwide productivity hit by inefficient communication.
	Part Quality & Downtime	- In-line part pass/fail at serial number level; identify asset issues, quarantine bad parts via time-stamped window; $30k/year sorting costs.
Data & Analytics	Real-Time Action & Granularity	- Ample OEE data, but struggle to act on real-time data instead of just reporting; visibility to problems lacks granularity.
	Labeling & ML Preparation	- Tedious labeling of raw data for ML models; need well-defined data for states, conditions.
	In-House Capability	- GE: 30k appliances/day, 1% velocity = $10M/yr; good OEE visibility via 3rd party, but want in-house analytics.
AI Adoption	Starting & Optimizing	- How/where to leverage AI to support humans; FOMO on AI; lack knowledge to optimize or get started.
Standardization & Tooling	CNC Programming & Tools	- Standardize CNC programming, tooling (e.g., Kirby); tooling pockets premium; reduced 16 facemills to 4-5 per machine.
Communication & Coordination	Inefficiencies & Structure	- B&L: too many managers affect communication; no single point of contact (SPA) for coordination; poor shift handoffs, delays in support.
Financial & Resource Optimization	Cost & Investment	- Companies resist new equipment spending; focus on good piece rate, max profits; link reduced downtime to $10M/yr savings.
	Fuel & Resource Use	- Optimize fuel usage in furnaces; maximize current resources for better performance.
Visibility & Solutions	Depth of Understanding	- Chasing true depth of problem visibility; can't solve unseen issues; OAK: good enough, extendable solution for manufacturers.

	Tracking & Systems	- Track equipment, locations, tasks assigned/performed; support workforce with effective systems.
Scheduling & Commitments	Delivery Issues	- Not meeting scheduled commitments, impacting operations and reliability.

Table 7: Summary of Productivity Group **Assets**

Category	**Key Assets**	**Details**
Technology Assets	Automation & Programming	- Automation team, CNC programmer, G-Code, back up program; process control, process-based scrap tracking.
	AI & ML Technologies	- ML-driven scheduling, ChatGPT, reduce burden in AI-ML tech; data analytics, online playbook/troubleshooting videos.
	Inventory & Monitoring	- Autonomous robotic inventory, OEE status for performance tracking.
People Assets – Company	Technical Expertise	- Machine Monitoring PLC, Controls Engineering, IS Support, engineering VP, mfg engineers, CNC programmers, data analyst.
	AI & Automation	- AI machine learning scheduling, brilliant factory, robotic cycle counting, AI vision systems, automation.
	Workforce & Support	- Operator effectiveness, multiple assets in 1 location with flexible skills for breakdowns; Henry Williams (maintenance engineer), JD Green, Matt Crochett.
	Strategic Funding	- Funding for smart manufacturing roadmap, MFT NEO cohorts.
People Assets – Market	Inventory & Technology	- Drone inventory management, robots scanning inventory, discrete locations; shoreline sensors, drone cycle counting at local manufacturer.
	Vendors & Platforms	- POKA, SSI, Rockwell, tooling vendors, make.com, trello.com; Conexus, Forge, mhub, plug and play, WHIN IAAS.
	Workforce & Grants	- Workforce development, grant writers, MRG grants, analytixIN - AI COP; Dave Roberts for expertise.
People Assets – University	Training & Interns	- MEP, Griswold Interns, PU interns, Yuseop Sim, Michael Yancy (Griswold Intern for comm system); MEP operator training, Poka AI mechanical training.
	Research & Collaboration	- Manufuture, Data Mine, industry labs at ND, SYBIS (NW Indy); business school projects, manufacturing focus.
	Data & Analytics	- Data analysts, data mining team, Eunseob Kim for research support.
Additional Assets – Peer Cohorts	Systems & Providers	- Oracle/FIS, Open AI, SSI (firmware controller), equipment providers in network; ecosystem mapping project.
	Collaboration & Knowledge	- MFT NEO WS#1 (operational effectiveness), WS#3 (capabilities sharing, strategy, growth); knowledge from adjacent industries.
	AI & Process Solutions	- AI agent for supply chain materials planning (Ron Norris solution); process control, CNC program delta detection (TMF).
	Unified Tools	- Unify Dave Roberts UI, Grafana dashboard, work instruction portal.

Additional Assets – OAK Solutions	Communication & Monitoring	- Communication system, machine monitoring, machine sensor data, part fingerprinting.
	Technical Infrastructure	- 1: Create diagram for Pi I/O, commission circuit board for Pi "plug n play"; 3: document, standardize workflow for make, sheets, trello, email.
	Unified Tools & Deployment	- 2: Unify Dave Roberts UI, Grafana dashboard, work instruction portal; 4: deploy OAK.
Additional Assets – Student Projects	AI & Data Solutions	- AI solution for materials planning, data mining team, IT team for support.
	Interns & Capstone	- Summer/semester interns, LZ (starting 1-2 weeks), ME capstone for hands-on projects.
	Logging & Unified Tools	- Service/PM/repair/breakdown logging to single point; 2: unify Dave Roberts UI, Grafana dashboard, work instruction portal.

Table 8: Summary of Productivity Group **Project Ideas**

Category	Key Ideas	Details
Peer Cohorts	Benchmarking & Collaboration	- Benchmark with GE Appliances; join NEO project to share successes, lessons learned.
	Inventory & Supply Chain	- Inventory management; supply chain cohort for responsive, collaborative supply-chain based on capabilities.
	AI & Process Improvement	- AI for material planning, floor-level equipment diagnostics; process control, new manufacturing methods.
	Monitoring & Communication	- Monitoring, dashboard for critical assets, feedback loop; interdepartmental communication system; CHARM integration.
	Automated Diversion	- Setup diversion gate, belt for bad parts, auto-triggered by furnace, belt speed for inspection.
OAK Solutions	AI-Driven Tools	- AI for material planning (GE Appliances), scheduling, procurement; ChatGPT 4.0 prototype solved complex scheduling in 1 hour.
	Maintenance & Performance	- Resolve maintenance issues; identify performance inputs; prescriptive solutions to optimize.
	Knowledge & Training	- Private LLM for knowledge sharing, problem solving; AI training of work content for younger workforce.
	Digital Thread	- Implement digital thread for connected processes, data flow.
Student Projects	Inventory & Analytics	- Improved inventory, coil management; Phase 1: build analytics tool for lost time from bad parts via furnace condition, diversion.
	AI & Predictive Tools	- Phase 2: incorporate AI into predictive tool; contrastive learning for 10 PB unlabeled data; 1 cycle to RUL.
	Automation & Standardization	- Tool management, automation, standardization projects; software automation for scheduling, capacity, scrap.
	Optimization & Detection	- Optimize current product line; incentivize data entry; use independent sound signals to detect operational state.

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Equipment Health Breakout

Table 9: Summary of **Meaningful Challenges** – Equipment Health Group

Category	Key Challenges	Details
Utilities & Infrastructure	Resource Systems	- Issues with chilled water, compressed air, material level-line side, conveyance, grinder blades, air, electric, steam, HVAC.
	Infrastructure Scale	- Large-scale deployment needs efficiency, efficacy; future-proofing for facilities; portable, wireless solutions desired.
Equipment & Maintenance	Aging & Diverse Equipment	- Aging plant, mix of old/new tools, diverse equipment; limited parts availability, equipment knowledge gaps.
	Downtime & Predictive Needs	- Reduce unplanned downtime (grinders, presses); develop predictive methods (e.g., temp sensors for bearings, gibs); track machine, die lifetime.
	Monitoring & Visibility	- Monitor new/old tools, spaces to catch problems early; increase visibility to developing equipment issues, electric motor failures.
	AM/PM Optimization	- Manipulate AM/PM process for trending, prevent recurring breakdowns via meaningful maintenance.
Data & Reporting	Downtime Data Accuracy	- Accurately capture, reconcile press downtime with work order data; sound not working, shift to vibration or other.
	Reporting & KPIs	- Centralize reporting for KPIs, metrics; visibility to asset condition for all stakeholders.
Scalability & Resources	Work Cell Scaling	- 100+ wirelines in Lafayette plant, similar work cells; solutions must scale easily for reliability.
	Resource Constraints	- Limited time, experience, capability, dollars; focus on best ROI, thanks Ted!
Cultural & Operational	Departmental Buy-In	- Dept buy-in challenges, "I told you so" mindset; cultural issues like wrangling a stallion, dragging a dead horse.
	Action & Adaptation	- Getting ops to act on anomalies; program adaptation for 24x7 continuous flow, autonomous/preventive optimization.
Cost & Technology	Expensive IoT Solutions	- Existing IoT offerings too costly for ~12,000 points to monitor; bagger, batch system a nightmare for cost, delivery.
	Future-Proofing & ROI	- Future-proofing for efficiency, efficacy; ROI concerns for initial steps, large-scale needs.
Specific Process Issues	Bagger & Downtime	- Finish line bagger, batch system issues; long downtime events impact cost, delivery.

Table 10: Summary of Equipment Health **Assets**

Category	Key Assets	Details
Technology Assets	Monitoring & Sensors	- Vibration analysis, IOT, IO-Link sensors, machine state monitoring for equipment health.
	Systems & Software	- CMMS system, CMMS software, Ignition SCADA, SCADA, PLC/HMI package, relational databases.
	AI & Integration	- Machine learning, Machine learning/AI, fully integrated ERP/machine network for streamlined operations.
People Assets – Company	Technical Expertise	- Automation/controls engineering, IT/OT, senior maintenance techs, reliability engineer, opex director, OT group.
	Leadership & Support	- Rob Bloomer, Danny Reed, Bob B., Cameron C.; maintenance personnel, interns, Team/RE/CI for continuous improvement.
	Specialized Skills	- Experience with past MES implementation, defining hardware/software for machine monitoring, criticality assessments.
	External Support	- ArR - Grants consulting firms to aid funding, smart manufacturing initiatives.
People Assets – Market	Vendors & Integrators	- IFM (vibration, sensors), Inductive Automation, System Integrators, vendors, key companies open to collaboration.
	Expertise & Resources	- Dale Nicholson, Kurt from IFM, state orgs, SoWE; BOM for HMI/PLC, FIIX CMMS for maintenance.
	Collaborative Networks	- WHIN, IFM, case studies for shared learning and insights.
People Assets – University	Students & Training	- Student knowledge, graduate students, Purdue, Ivy Tech, ManuFuture members for projects, collaboration.
	Capstone & Support	- Willing to work with student capstone group on sensor deployment; engineers, other supporting groups.
Additional Assets – Peer Cohorts	Sensors & Solutions	- IFM/IO Link, sensors/gateways, sensor solutions; vibration analysis needs basic training (e.g., Vibration 101).
	Shared Resources	- Software, hardware, tools from similar process companies (e.g., Tate and Lyle); shared experiences, prior projects.
Additional Assets – OAK Solutions	Monitoring & Interpretation	- Software to interpret vibration data, highlight developing problems; open-source, low-cost monitoring solutions.
	Communication & AI	- Kirby Risk's operator communication solution; AI for downtime, customer release changes; IOT integration.
	Open Source Preference	- Open-source community-built solutions preferred for cost, data control.
Additional Assets – Student Projects	Research & Development	- Vibration analysis knowledge, wireless vibration sensor development, 2025-2026 senior capstone project.
	Analytics & Automation	- Data analytics, AI projects, auto-reporting (Pareto, OEE) for insights; time to research best practices.
	Project Value & Limits	- Student projects fantastic, but time limited for larger initiatives.

Table 11: Summary of **Project Ideas** – Equipment Health

Category	Key Ideas	Details
Peer Cohorts	Sensor Fit & Monitoring	- Material level IFM ultrasonic sensors seem effective for tracking.
	Data & Communication	- Digital monitoring and communication; CMMS data trend analysis of work orders.
OAK Solutions	Analysis Tools	- Failure mode analysis; explore SPC, analytic tools for machine learning, training needs.
	AI & Predictive Alerts	- Use AI to analyze sensor data (e.g., temp) for predictive alerts, set limits to manage volume.
Student Projects	Vibration & Failure Detection	- Grinder blades: detect dullness, bearing failure via vibration analysis; anomaly detection.
	Machine & Environmental	- Machine-state monitoring, reporting; clean room: monitor air handling, water, waste, exhaust.
	In-House Data Modeling	- Purdue students used 3 data models for REA; explore in-house methods to avoid heavy data export.

Next Steps

Within the workbook, participants were asked about further participation within ManuFuture.

Table 12: Summary of participant engagement preferences

Question	Key Themes	Insights
1. Replicate ManuFuture Solution	Interest Areas	- 5 Continuous, 6 Discrete, 6 motors/compressors, 2 imaging; 1 no, 1 likely later, 17 no response.
2. Contribute to ManuFuture	Solution Offerings	- 10 Yes: communication, delta management, large data collection, real-time context, engineering capacity, implementation aid, PLC/HMI BOM, tote shaker.
3. Join ManuFuture Cohort	Focus Areas	- 6 Productivity, 7 Equipment Health; others open to future or as resources.
4. Ideas to Grow ManuFuture	Education & Workshops	- 3D printing education, AI workshops for SMBs to optimize queries and agents.
	Purpose & Participation	- Define community purpose, reasoning for sharing proprietary knowledge; great session, explore O.A.K. for insight.

Conclusion

The following actions are planned:

- **Workshop Report Distribution:** A comprehensive report (this document) will be shared with participants by mid-June 2025.
- **Cohort Workstreams:** Official launches in June 2025, focusing on productivity (e.g., communication systems, CNC standardization) and equipment health (e.g., predictive maintenance, vibration analysis).
- **Engagement Opportunities:** Invitations to join peer cohorts, contribute to O.A.K., and participate in student projects will be sent.
- **Follow-Up:** ManuFuture will host follow-up calls and events to sustain momentum, with a focus on scaling solutions and addressing challenges like cybersecurity and support capacity.

The May 14, 2025, ManuFuture Today Workshop was a pivotal step in fostering collaboration and innovation in manufacturing. By leveraging the O.A.K. Platform, sharing practical solutions, and forming challenge-based cohorts, participants laid the groundwork for transformative outcomes. The ManuFuture community remains committed to supporting manufacturers in achieving productivity and equipment health goals through peer learning and accessible technology.