Interdisciplinary Center for Advanced Manufacturing Systems

# MxD Sensor Kit Adoption Study

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# EXECUTIVE SUMMARY

The objective of the Interdisciplinary Center for Advanced Manufacturing Systems' (ICAMS) longitudinal research program is to provide insights that will accelerate the depth and breadth of smart manufacturing adoption to increase U.S. manufacturing competitiveness.

**Purpose and Scope**

This MxD Sensor Kit (MSK) case study, a part of the broader ICAMS initiative, captures the adoption process from the inception of a solution through its implementation. The lessons learned from this study are intended to inform the design of an adoption roadmap, significantly contributing to the acceleration of digital manufacturing adoption.

**Genesis of the Solution**

MxD has been promoting digital manufacturing since its inception as the Digital Manufacturing and Design Innovation Institute. Despite some success, many small- to medium-sized manufacturers (SMMs) struggled with understanding and adopting digital solutions due to high costs, resource constraints, and past negative experiences with large, costly solutions.

**Methodology**

The study is based on qualitative interviews with the MxD design and implementation team and three small manufacturers who installed the MxD sensor solution. These interviews provided valuable insights into the development, testing, and deployment processes of the MSK, which can be applied to improve industry-wide adoption of smart manufacturing technologies.

**Key Findings**

1. **Know your audience**: The MxD team engaged with SMMs to understand their challenges and needs, leading to the development of a simple, no-coding-required sensor kit that interfaces with various commercially available sensors.
2. **Lower adoption barriers:** Adoption of an innovation occurs when the motivation to use it is higher than the barriers. MxD lowered technology barriers with a simple yet flexible design and lowered value barriers by initially offering the MSK for free.
3. **Reduce complexity**: MxD developed a sensor kit that features an open architecture for flexibility and growth, and it does not require ongoing subscription services, making it more accessible to small- to medium-sized manufacturers (SMMs).
4. **Leverage peers for sales**: Peer acceptance is the leading driver of adoption, and MxD leveraged its team of engineers who were able to relate to and establish trust with prospective customers, facilitating rapid adoption.

**Conclusion**

The ICAMS Manufacturing Adoption Study and the MxD Sensor Kit case study provide a detailed roadmap for accelerating the adoption of digital manufacturing technologies. By addressing the specific needs and challenges of SMMs, these initiatives offer practical solutions that can significantly enhance the industry's overall adoption rate of smart manufacturing technologies.

## OBJECTIVE

Until the ICAMS Manufacturing Adoption Study, there had not been a comprehensive study to date of the adoption paths and rates of smart manufacturing by an industry. Such information is crucial to identify the status and state of industry in the technology adoption process.

The insights from the broader ICAMS study can be used to accelerate the depth and breadth of adoption and accurately measure adoption progress. This MxD Sensor Kit (MSK) case study was developed to capture the adoption process from the inception of a solution through its implementation. Lessons from this study can inform the design of an adoption road map, which could significantly contribute to accelerating the adoption of digital manufacturing.

## INTERVIEWS

This study was based on qualitative interviews, first with the MxD design and implementation team, followed by three small manufacturers that had installed MxD's sensor solution. All manufacturers were offered anonymity but chose to be identified to lend additional credibility to the effort.

## Interview #1: MxD

The process MxD used to develop, test, and deploy the MSK has yielded valuable insights that can be used to improve industry-wide adoption of smart manufacturing technologies. While the sensor kit is designed to provide an entry point into digital manufacturing, the lessons learned can be applied to the development and deployment of any technology.

### Genesis of the Idea

MxD has been encouraging manufacturers to embrace "digital manufacturing" since its initial launch as the Digital Manufacturing and Design Innovation Institute ten years ago. While some have heeded the call, many manufacturers aren't sure how that applies to their business or even how to start. This is particularly true for small- to medium-sized manufacturers (SMMs).

In 2023, the MxD team began to think about how to better help companies adopt digital manufacturing solutions. A significant hurdle was that SMMs often didn't understand many of the digital solutions and there wasn't an easy starting point that didn't incur significant consulting hours and costs. Additionally, the smaller firms typically don't have the resources to install or maintain solutions.

Another factor that hampered adoption was that many of the SMMs had been burned in the past by large solutions that were costly, required significant resources and often didn't deliver the expected results. These solutions also typically required subscription services, adding cost and further souring SMMs on the idea of digital manufacturing solutions.

As the MxD team was considering how to improve the adoption rate of digital manufacturing, the MxD board of directors challenged the team to implement digital

solutions at ten local manufacturers. This helped the organization focus on its mission and determine how to best tackle the challenge.

## Developing a Solution

The MxD team decided to develop a digital manufacturing solution that could be a starting point for companies, allowing for easy installation and configuration. Any technology used would need to have an "open architecture" to allow for modifications and to enable the solution to grow. Not only did the solution need to show clear value to SMMs, but it also needed to deliver that value without requiring an ongoing subscription service.

MxD engineers took to the drawing board and developed the idea for a sensor kit that could meet a wide variety of requirements in many different manufacturing environments. The first step was to meet with SMMs to understand their manufacturing challenges, what solutions they would most value, what might motivate them to adopt a solution, and what barriers would keep them from adopting any solution.

Coupling target customer input with their engineering expertise, the MxD team designed a simple sensor kit that requires no coding yet could interface with many commercially available sensors. In addition to a backplane that allows for both digital and analog inputs and outputs, the kit provides a Human-Machine Interface (HMI) to simplify its use. The MSK was designed to solve many different manufacturing issues and to be relatively simple to install and maintain by someone with knowledge of the manufacturing systems.

## Testing the Solution

Once the initial MSK device was made, the solution had to be alpha-tested in-house. Coincidentally, MxD had a compressor fail, creating an "Aha" moment. The sensor kit had already been created, so the team recognized this as a great opportunity to test the device. They used a piezoelectric sensor to monitor vibration of the unit, providing real-time, data-validated status of the equipment. That experience helped set the stage for using the kit with a variety of sensors to monitor flow, pressure, voltage and much more.

In one of the beta tests, a small manufacturer was having a problem with a coolant pump clogging. The company was spending $120 per month on maintenance, and it was tying up the production manager's time. Using the MxD sensor kit with a current sensor and attaching it to a stack light with an alarm, the sensor kit was configured to shut off the pump before it became clogged. Alerted by the alarm, the team would then remove and clean the pump, quickly restoring operations without costly replacement parts.

## Deploying the Solution

The MxD team knew that one of the most powerful drivers of innovation adoption is peer acceptance. The team set out to identify ten local manufacturers who would receive an installed kit at no cost, provided they would consent to have a case study written. They solicited volunteers from a few SMMs that they believed to be a good fit. MxD also showed off the sensor kit in its "future factory" facility, demonstrating how it could be used in a few specific examples but also explaining the versatility that allowed it to be applied to many different situations.

One of the companies interviewed for this piece explained that part of the attraction for them was that there wasn't a sales pitch for a particular solution. Rather, it felt like more of a conversation where the MxD team was asking questions and helping the prospective customer figure out where the sensor kit might provide the greatest value. This approach not only helped solve the problem, but it also gave the company greater ownership of the solution.

### Lessons Learned

One of the most significant lessons for MxD in driving adoption is that there needs to be a champion inside the target manufacturers. While that person doesn't need to be a senior executive, they do need buy-in from engineers and operators. The key is that this champion must help those on the shop or plant floor understand how this solution will help them.

Another lesson is that the existing processes to be monitored by the MSK must be documented correctly. In a few cases, reports about the MSK not working turned out to be an issue with process documentation. This led the MxD team to take a few extra steps to help customers validate their processes.

A lesson that many would never think of is that the legal agreement for use of the MSK must be simple. Complex agreements that require significant legal review incur costs and time – two things that are in short supply for most SMMs. Simpler agreements help lower this barrier to adoption.

### Value of the MSK

The MSK has been a great starting point, both for SMMs to begin the journey of digital manufacturing adoption and for MxD to better understand how to ignite and accelerate that adoption. One of the biggest advantages cited by MSK users is that they now "get it." The kit becomes a steppingstone that helps users better understand the possibilities of digital manufacturing and how it might benefit their organization. Since the MSK was designed as a building block, companies can easily add functionality and expand coverage to other equipment and processes.

The MSK also is helping capture tribal knowledge through the data that it gathers, which is very important with an aging workforce. One company that was about to move was concerned that some of the workforce wouldn't move with them. Data from the MSK sensor helped overcome that problem, providing data that made it easier to bring on new workers.

## Interview #2: Ergoseal (www.ergoseal.com)

Ergoseal is a small manufacturing firm that produces industrial parts and has about 25 employees.

### What challenges were you experiencing?

Ergoseal was experiencing problems with welded components. Two pieces often wouldn't be welded together correctly, with some pieces just popping off. "One of the

problems is that we didn't know exactly the temperature and duration, so sometimes operators would simply crank up both."

This issue had been going on for several years and the leadership was aware of the problem. The company tried buying higher grade materials, hoping that might solve the problem, but it didn't.

### How did you learn about the sensor kit?

Chris Verni, Ergoseal's chief operating officer (COO), was visiting MxD when they showed the MSK and asked if anyone would be interested in trying it. The company's leadership had already been pushing to move into Industry 4.0, so the COO thought this might be a way to start small and get the team comfortable.

### What was the sensor kit implementation process?

The MxD team did a walk-through of Ergoseal to understand the challenges and collaborate on options. Two sensor kits were installed in the fall of 2023 and implementation was very simple. The MSKs were configured off-site and then the MxD team came onsite to install them.

In less than a day, the installation locations were determined, with one MSKs set up on the welder and another to monitor coolant levels. Tests were then run so that a baseline could be established. The COO expressed that MxD had been great to work with and the implementation went smoothly.

### What has been their experience using the sensor kit?

Welding efficiency has increased since the company installed the MxD Sensor Kit. They can now use data to narrow down issues to the material or the process. Six-hour jobs were cut to five hours. The quantity of materials, such as welding probes, was also reduced. Quality also improved, dropping from a seven percent scrap rate to now next to nothing.

No support has been needed since the units were installed. MxD visited once to check performance and made a slight adjustment, but otherwise, Ergoseal has been able to utilize and maintain the sensors in-house.

As expected, the MSK was a good steppingstone to learn about other Industry 4.0 technologies. The company has since installed a robotic arm and is considering other technologies tied to quality and inspection.

## Interview #3: Meliora Cleaning Products (www.meliorameansbetter.com)

Meliora Cleaning Products is a small product manufacturer with fewer than 20 employees.

### What challenges were you experiencing?

Meliora Cleaning Products is a small soap and cleaning products manufacturer with limited automation, relying heavily on small scale equipment. While the owner is a Six Sigma Black Belt and they have focused on process improvement, the company hasn't explored Industry 4.0 technologies. There really wasn't a specific challenge the company was looking to address, but rather an interest in learning more about the technologies and how they might help the firm.

### How did you learn about the sensor kit?

Kate Jakubas, one of the company's co-founders and chief operating officer, was attending an event at MxD, where they provided a demonstration of the MSK. The MxD team asked, "Is this something that could be useful on your plant floor?" Seeing the demo helped Kate better understand the kit's value and the opportunity it presented.

Despite the MSK seeming "space-agey," it became clear that this device could help make product measurements easier. The company was not capturing the necessary metrics manually, so this would be a new process.

### What was the sensor implementation process?

MxD came onsite and installed the kits. Within an hour of arriving, they were already getting results and making adjustments.

### What has been the experience using the sensors?

The MSKs were placed on equipment that had been overheating to help diagnose the problems. The sensors haven't helped pinpoint exactly what was going on, but they helped the company better understand some of the ongoing challenges. Experience with the MSK has also helped influence choices on other equipment by evaluating things like amperage and temperature.

## Interview #4: M.K. Morse (www.mkmorse.com)

The M.K. Morse Company is a medium-sized manufacturing firm that produces industrial cutting products and has about 400 employees.

### What challenges were you experiencing?

One of the challenges facing M.K. Morse is how to make sure products are made consistently so that performance meets expectations. This requires inspecting products in such a way that the team can look back and observe trends from the production process to use in the field.

An example was an optimum part that is exactly one inch long and is beginning to drop in length over time. That is a trend that likely indicates a change in quality or performance. The team began looking for accurate sensors that could provide the data needed to understand what was happening.

The company also organizes and participates in conferences around the world, where they get insights into the use of the company's products and they can gather customer

insights. While capturing tribal knowledge is helpful, the key is finding a scientific solution that is repeatable.

### How did you learn about the sensor kit?

The research and development leadership of M.K. Morse was visiting MxD and saw the sensor kit demonstrated there. Based on the initial discussions with MxD, it was decided to bring the MxD Sensor Kit (MSK) into the lab to test the kit and see how it might be used to train employees.

### How is the sensor kit being used?

M.K. Morse has a unique use for the sensor kit – placing it in the lab to help train employees on sensors. The MSK helps employees understand how sensors work, their usefulness, and how to use them correctly.

The MxD sensor kit is being used to help teach employees how to troubleshoot manufacturing problems. In one example, a thermal sensor on a machine was reading 1100C. The operator was reporting this as an urgent problem, not realizing that it wasn't possible since the material would have melted at that temperature. After checking and replacing the sensor, the problem was resolved.

The company plans to use the sensor kits in the future for research and development in the lab. There is recognition that these kits are ideal for ensuring quality and that collecting information from sensor kits on the production line could help solve problems.

One of the uses envisioned for the sensor kits is future research and development. The sensors are ideal for tracking quality since collecting information and watching for trends is critical. The MxD sensor kit could help significantly improve product quality and yields.

## FINDINGS

While this study was limited in scope, the findings were significant. Tracing the successful development and deployment of a digital manufacturing solution has yielded valuable insights. The following are some of the major findings.

### Know your target audience

Knowing the needs of your audience before designing a solution is a standard practice. What is often missed but was addressed by MxD is understanding how that solution will be used and the barriers to its adoption. Having worked with many SMMs, MxD already knew that the solution had to be simple to use and maintain. They learned from early discussions that companies had been burned by large expensive solutions that didn't deliver. The MxD team also learned that this led to an aversion to solutions that required subscription services. Taking those factors into account during the design process helped design a product with lower barriers to adoption.

## Start simple with the ability to grow

When designing a new product, there is often a tendency to try and develop very robust solutions that can solve many challenges. The difficulty is that robustness typically involves complexity, increasing the time and effort needed for adoption. By starting simple but choosing an open architecture that made it easy to add features later, the MxD team developed a solution that was easy to understand and implement.

This approach had an added benefit. Since the solution is really a building block that could be configured in multiple ways with commercially available sensors, the customer could determine how the solution might best serve them and in what configuration.

## Rely on peers for consultative sales

Many sales courses teach how to sell benefits over features or the best way to handle objections. What they typically don't provide is the experience of being in the shoes of those you're selling to. That's the value of relying on someone your prospective customer considers a peer.

The team explaining and demonstrating the MSK was comprised of MxD engineers experienced in manufacturing rather than salespeople. These engineers had a level of manufacturing experience that helped them earn the trust of potential users. That experience also enabled a consultative dialog, with MxD engineers asking questions that led to a greater understanding of the user's needs. This approach differed greatly from the traditional sales pitch by the companies selling large, complicated solutions. Several of the companies interviewed noted and appreciated that difference.

## Lower adoption barriers

Adoption of an innovation occurs when the motivation to use it exceeds the perceived and real barriers. In the case of something new that may not be fully understood until it has been used, like many digital manufacturing technologies, motivation may not be high in the beginning. To overcome this hurdle, adoption barriers must be reduced as much as possible.

MxD recognized this challenge and began addressing adoption barriers in the design stage. The design of the MSK was simple yet flexible, allowing customers to readily recognize the product's value and configure it for their specific needs. That flexibility increased the value of the product and the motivation to use it. The design also allowed for simple installation and required little maintenance, reducing cost, effort, and risk.

The structure of the offering also lowered barriers. First, it was offered at no cost to the ten test sites with a simple requirement to allow customer case studies to be developed for marketing. Second, using the MSK did not require an ongoing subscription, further reducing costs and overcoming a frustration customers had voiced from previous experiences. Finally, since the MxD team has considerable experience with SMMs, they understood that legal resources were costly and that a complex user agreement could be a stumbling block. They chose instead to offer a very simple user agreement.

### Leverage Peer Acceptance

As documented in previous ICAMS studies [1] [2], peer acceptance is a leading factor in driving adoption of innovations. Individuals are more interested in and likely to trust solutions that are being used by individuals and companies they consider to be peers.

By asking for customer stories from the ten initial companies deploying the MSK, the MxD team is positioned to use those customer stories to not only spread word of the value of this technology, but also leveraging what others in the industry will view as peer acceptance.

## CONCLUSION

The team at MxD has clearly taken steps that have helped accelerate the early adoption of technology in manufacturing with the MSK solution. With a current goal of installing 100 more, much of the focus will be on those new installations. Leveraging the experience of the first ten installations and the accompanying customer stories should certainly help broaden the base of MSK installations.

However, MxD should also find ways to continue working with the installed base to strengthen MSK adoption. Dr. Everett Rogers defined adoption as “making full use of an innovation. [3]” While the companies interviewed have a long way to go before they will make full use of the MSK, they are already receiving value from the product. Efforts to help companies with MSK installations find new and more powerful uses for the solution will help those companies realize even greater value and better position MxD to accelerate both the depth and breadth of adoption.

## REFERENCES


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