INNOVATIE NU

September 2025

15

MOVING TOWARDS INTELLIGENT MANUFACTURING

UNIVERSITY OF TWENTE | FRAUNHOFER INNOVATION PLATFORM
FOR ADVANCED MANUFACTURING

Explore how your organisation can *unlock the power of AI* in manufacturing!

Whether you are just beginning to explore AI or already testing its potential, the practical

AI Guide

provides the insight and structure needed to progress with confidence.

Identify the most suitable AI focus for your organisation, whether it is machine learning, predictive maintenance, generative AI, or quality control enhanced by AI, the AI Guide lays the foundation for intelligent and sustainable growth.

Key Benefits:

- *A clear overview of the company's readiness for AI*
- *A tailored roadmap that aligns with specific business goals*
- *Greater clarity on where AI can create the most value*
- *Practical experience with key tools to initiate implementation*

Let's turn AI potential into measurable progress together!

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Dear reader,

The manufacturing landscape is undergoing a profound transformation driven by the convergence of artificial intelligence (AI), the Internet of Things (IoT), and advanced production data analytics. Our fifteenth issue of InnovatieNU explores the growing field of production intelligence—where smart technologies are integrated into the production and product lifecycle to enhance efficiency, adaptability, and human decision-making.

Each article presents a different facet of this transformation, from the early stages of generative design—where AI assists engineers in creating optimized, innovative solutions—to the dynamic environments of smart factories, where real-time data powers intelligent automation and responsiveness. The role of AI in smart production planning is also highlighted, enabling manufacturers to anticipate demand, allocate resources effectively, and navigate complex supply chains with unprecedented agility.

Central to the discussion is the role of AI not as a replacement for human expertise, but as a powerful support tool. These technologies amplify human capabilities by offering insights, recommendations, and efficiencies that empower workers and engineers to make better-informed decisions. As discussed in this magazine, AI comes with its own challenges —privacy, lack of human nuance, and transparency— which are especially relevant in industrial contexts. These topics are critical to the discussion on how to develop an ethical implementation of AI in your organisation.

By weaving together IoT-enabled data streams, machine learning algorithms, and human ingenuity, this issue of InnovatieNU presents a forward-looking vision of production intelligence. It is a call to embrace AI and digital technologies not just for automation, but for augmenting the people who drive innovation in manufacturing. The goal is not just smart factories—but also responsible, ethical, and transparent ones. Production intelligence, when guided by human values, can drive sustainable innovation while safeguarding trust and integrity in an increasingly automated world.

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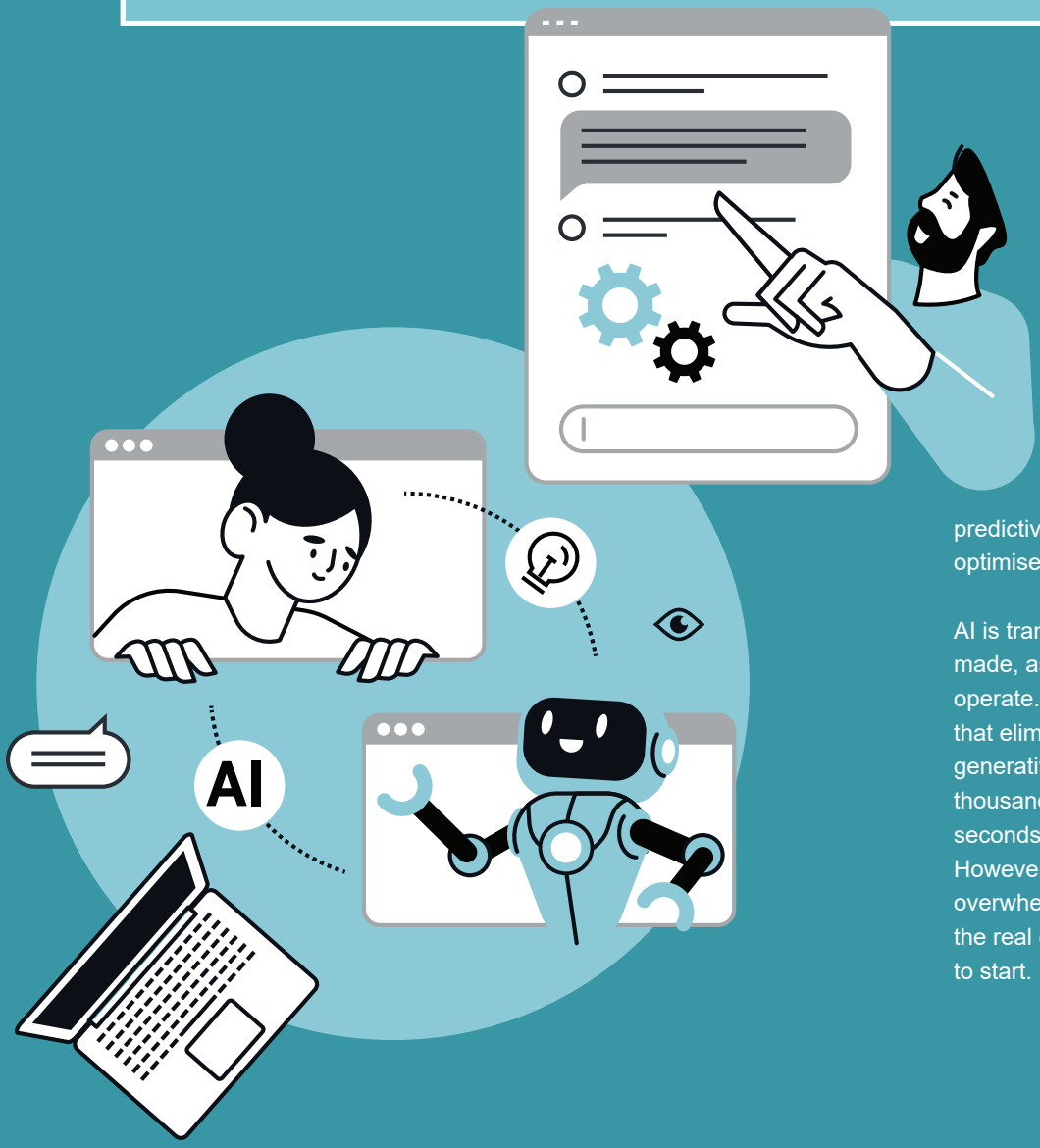
PRODUCTION INTELLIGENCE IN ACTION

HOW AI IS RESHAPING MODERN MANUFACTURING



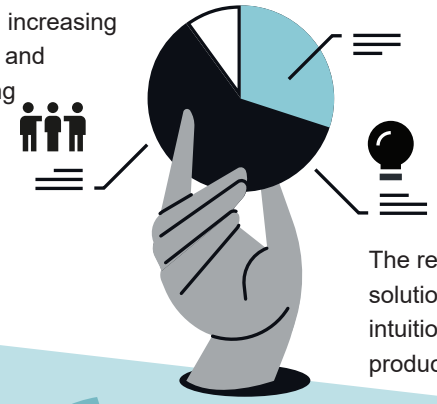
In a factory not far from here, machines no longer simply follow orders. They learn from them. A new era of smart manufacturing is emerging, driven by artificial intelligence (AI). What was once manual and reactive is now becoming predictive, autonomous, and constantly optimised.

AI is transforming how products are made, as well as how manufacturers operate. From predictive maintenance that eliminates costly downtime to generative design tools that explore thousands of product variations in seconds, AI is changing the game. However, the pace of change can be overwhelming. For many businesses, the real challenge lies in knowing where to start.

From Automation to Transformation

AI is no longer just a tool for automating repetitive tasks. It has become a true driver of transformation. With rapid advancements across the entire AI spectrum, including classical machine learning, predictive analytics, and cutting-edge generative AI, manufacturers now have access to powerful capabilities. These can improve efficiency, enhance quality, and unlock entirely new ways of working.

One of the most impactful applications is predictive maintenance, where AI analyses machine data to detect early signs of failure. This enables proactive intervention and significantly reduces unplanned downtime and maintenance costs. At the same time, AI-enhanced quality control uses computer vision to inspect products in real time, increasing accuracy and minimising waste.



Smart Factories and Smarter Decisions

At the heart of this transformation is the Smart factory. In these environments, interconnected systems and sensors continuously feed data into AI models that optimise operations in real time. Decisions that once relied on manual oversight are now automated, adaptive, and fast.

However, turning raw data into real value requires more than installing sensors or software. It demands an understanding of how ready your organisation is from a technical, cultural, and strategic perspective to adopt AI in a meaningful way.

Generative Design: Unlocking New Possibilities

AI is also pushing the boundaries of design. Generative design tools allow engineers to input key constraints such as materials, cost, or strength, and then explore thousands of options. The result is a set of highly optimised solutions that extend beyond human intuition and significantly accelerate product development cycles.

These tools are not replacing designers. Instead, they are becoming creative partners that open up entirely new possibilities.

Begin with the AI Guide

While the potential of AI is immense, successful adoption requires a clear and structured roadmap. Many companies are keen to explore AI but struggle to identify how or where to begin. Without a thoughtful approach, companies risk costly missteps or missed opportunities.

This is where FIP-AM@UT's **AI Guide** comes in. It is a practical, expert-led service designed to help organisations assess their readiness, identify promising use cases, and build a tailored AI strategy.

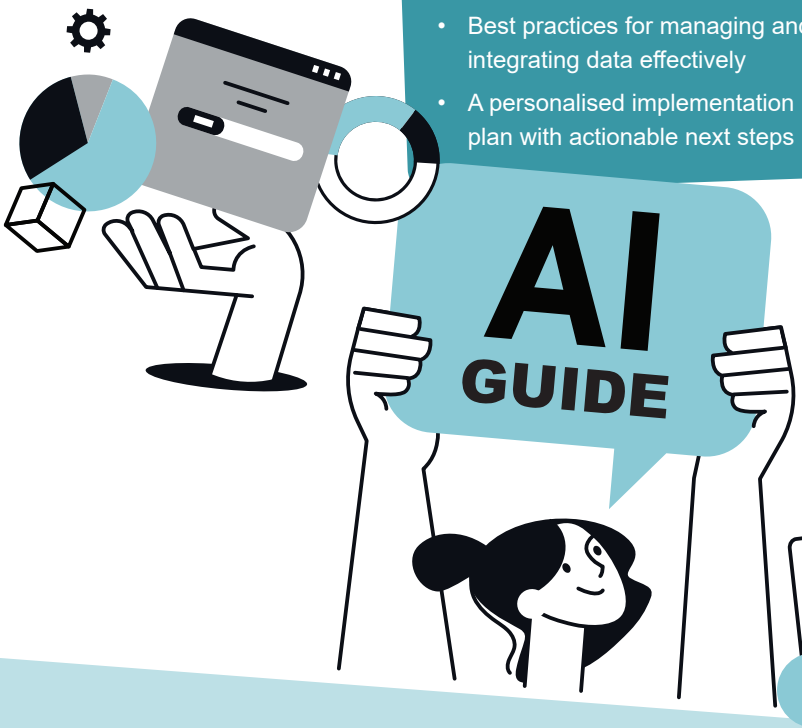
However, turning raw data into real value requires more than installing sensors or software. It demands an understanding of how ready your organisation is from a technical, cultural, and strategic perspective to adopt AI in a meaningful way.

What Is the AI Guide and What Does It Offer?

The AI Guide is a structured support service that simplifies AI adoption. It focuses on what is most feasible and valuable for your particular operations.

Participating companies can expect:

- A data-based analysis of existing systems and capabilities
- A collaborative process to identify high-impact opportunities for AI
- Best practices for managing and integrating data effectively
- A personalised implementation plan with actionable next steps
- Clear guidance on the benefits, challenges, and transitions required
- Interactive sessions using proven AI tools and technologies
- Practical strategies for cost reduction, improved accuracy, and scalable growth



Identify the most suitable AI focus for your organisation, Whether it is machine learning, predictive maintenance, generative AI, or quality control enhanced by AI, the AI Guide lays the foundation for intelligent and sustainable growth.

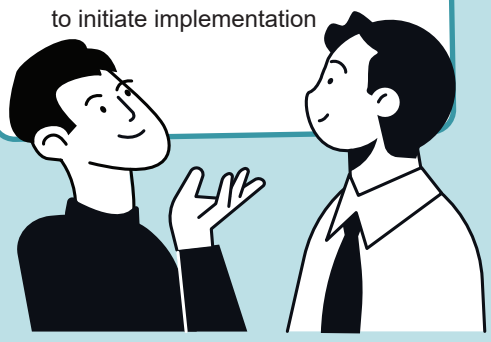
Why and When Should Companies Use the AI Guide?

The AI Guide supports manufacturers at multiple points in their AI journey. It is especially useful when your company:

- Is curious about using AI but uncertain about the first steps
- Has data and processes that could benefit from optimisation
- Wants to build internal understanding before committing to major investments
- Aims to make quicker and more informed decisions through AI-powered insights

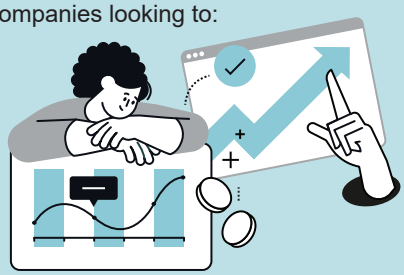
By using the AI Guide, companies will benefit from:

- A clear overview of their current readiness for AI
- A tailored roadmap that aligns with specific business goals
- Greater clarity on where AI can create the most value
- Practical experience with key tools to initiate implementation

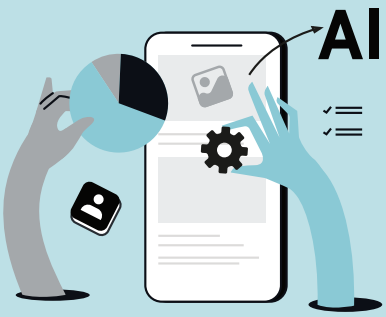


Who Is It For?

The AI Guide is designed for manufacturing companies looking to:



Boost productivity and efficiency across production lines



Identify processes that could be enhanced through AI

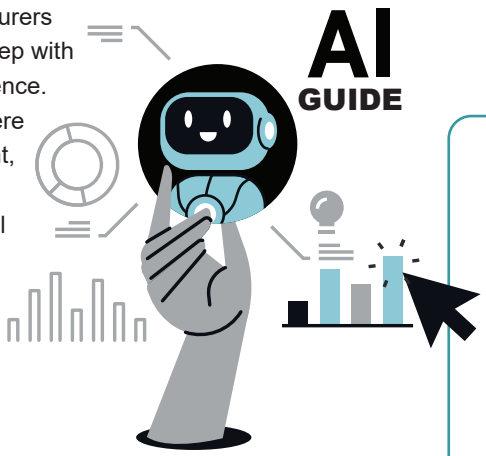
Innovate and remain competitive in a rapidly changing market

Whether you are just beginning to explore AI or already testing its potential, the AI Guide provides the insight and structure needed to progress with confidence.

Turning Potential into Progress

AI is redefining modern manufacturing. It is driving new levels of efficiency, precision, and innovation. Yet unlocking its full value requires more than interest or investment. It demands insight, a structured approach, and a well-defined path forward.

The AI Guide offers exactly that. It is a practical, expert-led service that enables manufacturers to take the next step with clarity and confidence. In an industry where change is constant, those who take a smart first step will lead the way into the future. ▪



Let's turn AI potential into measurable progress together.

Ready to Take the First Step?

To explore how your organisation can unlock the power of AI in manufacturing, reach out today.

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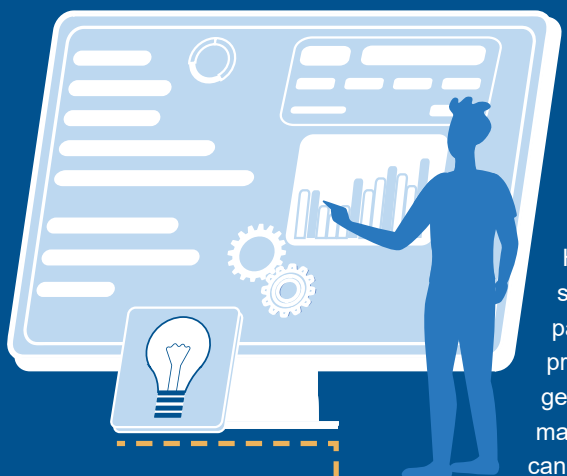
FROM DATA STREAMS *TO* STRATEGIC VALUE

Most SME factories already generate large amounts of data from machines, spreadsheets, or your team's daily reports. However, this data is often fragmented, difficult to access in isolated machines, spreadsheets or legacy systems, and often fails to support decision-making. This prevents SMEs from using their data to make informed decisions and improve production efficiency. Through the integration and connection of digital technologies and systems, manufacturers are transforming how they operate and make decisions.



Before digitalisation solutions such as AI and digital twins can support in this transformation, the data that is available must be connected, contextualised and made usable across the organisation. Digitalisation solutions require accessible, reliable and structured input to be effective. The first step is what industry often calls "horizontal and vertical integration", connecting machines, sensors, enterprise systems, and human operators into a coherent digital environment.

The greatest value emerges not simply from integrating and exchanging data, but from generating actionable insights. This shift from basic connectivity to production intelligence is key for SMEs striving to remain competitive in a fast-changing landscape.

Having actionable insight into the shopfloor can help SMEs move from passive data collection and reactive problem solving to active insight generation and proactive decision-making. For example, AI algorithms can detect patterns in production lines that even seasoned engineers may overlook. These insights, when integrated with information from the shopfloor and its environment, enable quicker and more informed decision-making such as adjusting maintenance schedules and redesigning workflows.

Achieving this transformation requires more than just implementing new technology. It involves governance, alignment between IT and operations, and a leadership mindset that treats data not as a by-product but as a driver of business performance.

Digital Twinning: The Smart Core of Information-Driven Manufacturing

Once systems are integrated and data is accessible, digital twinning provides the next leap. A digital twin is a virtual replica of a physical asset, process, or system. But its true power lies in how it learns and evolves using data, creating a dynamic environment for analysis, simulation, and prediction.

Recent research, published in Journal of Manufacturing Systems, outlines a structured digital twinning approach tailored for manufacturing SMEs . The key insight: SMEs do not need massive investment or fully autonomous systems to benefit. Instead, they need solutions that deliver the right information, when it matters most, and deliver only the information that is relevant.

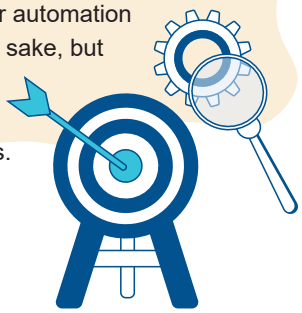
The development of a digital twin of a critical production process, for example, allows SMEs to test out new batch configurations, predict maintenance needs, or simulate the impact of planning changes, all without disrupting the actual operations. By combining live data, models, and domain expertise, such a solution can empower SMEs to make complex decisions faster and with greater confidence.

Successful implementation depends on three things. First, data must be accessible and reliable. Second, the system should be developed around the needs of the people using it. Third, progress should be made in small, manageable steps that deliver value early and often.

Practical Lessons and Next Steps for SME Leaders

Digital transformation is not purely a technical project, it's a business transformation. Based on both industry cases and our applied research, here are some lessons learned for decision-makers:

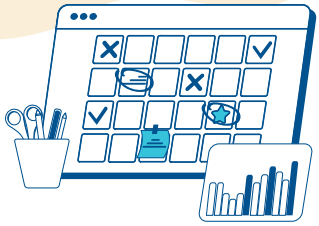
1 Start with a clear vision of how digitalisation will improve your business. The goal is not to adopt AI or automation for its own sake, but to solve specific challenges.



2 Start with a business problem, not a technology solution. Whether it's reducing scrap rates, shortening lead times, or increasing throughput, tie your technological investments directly to the needs and goals of the organisation.

3 Build the capability, not just the system. Investing in people, whether through training, partnerships with universities, or hiring data-savvy engineers, is essential. The best results come when technology complements human expertise rather than replacing it.

4 Iterate fast, but with structure. Pilot projects with clear boundaries (e.g., one machine, one KPI, one product line) allow teams to learn and adjust quickly.



5 Encourage cross-functional collaboration. IT, operations, and management need to align on objectives and responsibilities. Make sure that the departments and employees that use the systems and solutions become responsible for its development and implementation.

6 Don't do it alone. From regional innovation hubs to European research consortia, there is strong momentum to support SMEs on this journey. Leveraging external expertise can accelerate progress without overstretching internal resources. Don't hesitate to visit other companies and share experiences about how current technology can be implemented, there are many valuable lessons about digitalisation that companies are more than willing to share if you ask.

Production Intelligence as a Strategic Enabler

In today's competitive landscape, data is not just a technical resource. It is a strategic asset. SMEs that use their data wisely can improve flexibility, strengthen decision-making, and build more resilient operations. The goal is not to match the capabilities of the largest manufacturers. Instead, SMEs should adopt the technologies that fit their needs and scale.

Digitalisation solutions are not the end goal. Better planning, fewer delays, and more resilient operations are. SMEs that act now and begin turning data into meaningful insights will outperform those who wait. ■

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SMART, GREEN, AND COMPETITIVE

AI-HUB EAST NETHERLANDS AT THE HEART OF INDUSTRIAL AI

AI HUB East Netherlands

Europe's industry stands at a crossroads. Confronted with the twin transitions of Green and Digital, the continent is being called to reinvent itself. These transitions are not just policy ambitions, they are the backbone of the European Commission's long-term strategy for global competitiveness and sustainability. This urgency was emphasized in the 2023 Draghi Report by the former Italian Prime Minister Mario Draghi at the request of the European Commission.

The report, officially titled "Report on the Future of European Competitiveness", warns that Europe cannot afford to wait. If Europe are to close the productivity gap and secure our economic future, we must invest boldly in innovation. And in no area is that investment more urgent than artificial intelligence (AI).

For the East Netherlands region, known for its dynamic high-tech and manufacturing industry, the rise of AI is both a challenge and an opportunity. The deployment of AI promises smarter production, more efficient resource use, and stronger international positioning. But it also requires organizational readiness, digital infrastructure, and bold strategic choices. The time to act is now.

Laying the Foundation: Why Data Readiness is the Real Starting Point for Industrial AI

"Without structured data, AI has nothing to build on," says Frank Dikker, founder of TransAI, a platform that enables manufacturers to deploy AI securely on-site.

"Digitalization is not just a first step — it's the foundation."

TransAI's hybrid solution connects machines, systems, and operators, allowing data to be collected and processed without leaving the factory. This approach ensures compliance and control — two factors that remain critical in the manufacturing sector.

Peter Nales of Smart4Factories underscores the same principle from an organizational perspective:

> *"Without a solid digital foundation, AI remains a promise without results."*

His company works with SMEs to build this foundation step-by-step, connecting digital ambitions to operational reality.

> *"First organize, then digitalize,"*

is the mantra.

That view is echoed by Jeroen Linssen, professor at Saxion University of Applied Sciences.

> *"What you see in AI applications is just the tip of the iceberg. Before you can operationalize AI, your processes must be made truly data-driven,"*

he explains. That transformation requires more than software — it demands technical infrastructure, governance, and cultural change.

The urgency is clear. As Erik Fledderus from Windsheim puts it,

> *"Without data readiness, there is no business case for AI."*

In East Netherlands, this insight is increasingly taking root — not just in the labs, but on the shop floor, where AI's true potential begins with the basics.

From Potential to Practice: Where AI is Already Delivering in Industry

In East Netherlands, AI is no longer a future promise but it already delivering results today. While much of the global AI spotlight shines on consumer tech, some of the most impactful advances are happening on the factory floor.

"The first AI applications we see in industry are focused on efficiency," says Michiel Verheij of digital agency TRIMM. "Predictive maintenance, real-time forecasting, and yield optimization are no longer reserved for the big players — SMEs can now tap into them as well."

These are not abstract ambitions. At Smart4Factories, engineers are co-developing an AI agent that assists production planners by learning from high-quality process data. "It's like having a digital co-worker," says Peter Nales. Meanwhile, Saxion is applying large language models to make technical manuals more usable for maintenance personnel — an innovation with direct impact on uptime and safety.

But the real value of AI isn't only in doing things faster or cheaper. "AI enables new business models," says Verheij. "The challenge is not just in efficiency, but in imagining new forms of value creation."

For smaller manufacturers, this journey requires support and pragmatism. As Erwin Folmer of HAN notes, most SMEs will do not have dedicated AI departments or in-house expertise. They depend heavily on accessible tooling and foundational knowledge — and organizations like HAN are helping them build precisely that.

From predictive algorithms to cobots and intelligent quality control, East Netherlands is becoming a testbed for industrial AI — and the momentum is just beginning.

Beyond the Tool: Organizational Strategy and Business Modeling in the Age of AI

Implementing AI in industry is not just a technical upgrade — it's a strategic transformation. As Michiel Verheij of TRIMM puts it bluntly: "A fool with a tool is still a fool." Providing employees access to AI tools isn't enough. The real challenge lies in aligning AI adoption with organizational vision, culture, and leadership.

AI is a system technology — one that cuts across departments, workflows, and even entire business models. "Ownership must lie with top management," Verheij insists. "You can't delegate AI strategy to middle management or IT alone. It affects how value is created, who makes decisions, and how people work."

For many SMEs, this transformation can be overwhelming. Many lack in-house expertise or fear uncertain returns. That's why institutions like Windesheim, Saxion and HAN are stepping in with hands-on support: training programs, applied research, and access to shared high-tech facilities. Their aim is to turn AI from an abstract concept into a concrete capability — something that drives strategy, not just operations.

Peter Nales of Smart4Factories describes digital transformation as "a continuous learning process," rather than a one-off project. Vision, structure, and collaboration are key. In that light, AI isn't simply about automation or cost-cutting — it's a chance to rethink the business itself. From data-driven services to AI-powered customization, companies are beginning to explore new revenue streams and operating models.

In East Netherlands, AI is not an add-on. It is becoming the lens through which strategy and innovation are reimagined.

Connecting the Dots: The Role of AI-hub East Netherlands

The AI-hub East Netherlands plays a pivotal role in helping the region's industry seize the opportunities of artificial intelligence. By connecting

From predictive algorithms to cobots and intelligent quality control, East Netherlands is becoming a testbed for industrial AI — and the momentum is just beginning.

entrepreneurs with researchers, funding programs, and practical examples, the hub makes AI tangible and attainable, especially for SMEs.

Its approach is practical and hands-on: from showcasing success stories to supporting test environments and co-funded pilot projects. The goal is clear — lower the barriers to adoption and accelerate AI maturity across sectors. Or as the hub puts it ‘Make AI Work’.

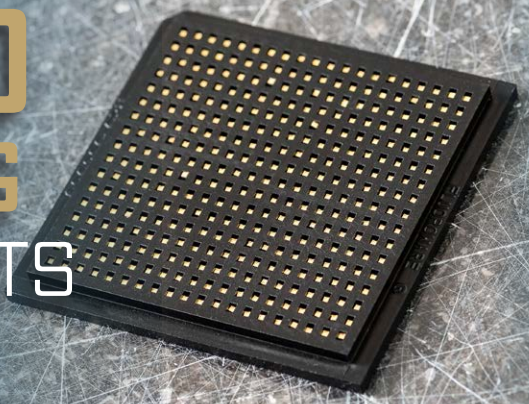
More than a regional enabler, the hub also serves as a gateway to national and European initiatives, linking local innovators with networks like EDIH BOOST Robotics, the Vanguard Initiative and the AI Redgio project.

With strong roots in East Netherlands’ innovation ecosystem, the AI-hub ensures that companies have access to the knowledge, tools, and partnerships needed to move from ambition to action — and from potential to competitive advantage. ■

> **The AI-hub East Netherlands plays a pivotal role in helping the region’s industry seize the opportunities of artificial intelligence.**

Want to start with AI?
Check the webpage www.aihub-oost.nl

AI-ENHANCED ORDER SCHEDULING OF HIGH-END COMPONENTS FOR THE SEMICONDUCTOR INDUSTRY



The growing importance of semiconductors directly impacts the demand for high-end components in their supply chain. In particular, the requirements for these components need to be tailored to various applications. This high level of customization introduces greater complexity and flexibility into the manufacturing process. In particular, this creates challenges for cost-optimized scheduling of orders, machines and personnel – an optimization problem known as order scheduling or production program planning. MINTRES B.V. has therefore joined forces with Fraunhofer Institute for Production Technology IPT and Fraunhofer Innovation Platform for Advanced Manufacturing at the University of Twente (FIP-AM@UT) to develop an intelligent production program planning module for their Enterprise Resource Planning (ERP) system.

Introduction and Challenge

The semiconductor industry provides essential components for new technologies. Advances in artificial intelligence (AI), the Internet of Things (IoT), and 5G rely heavily on this sector. It serves as both a key enabler and a driver of innovation for these fields. As a result, the growing demand for advanced technologies is also amplifying the importance of this rapidly evolving industry. In recent years, it has also become clear that disruptions in semiconductor supply can cause breakdowns across global supply chains.

Mintres B.V., headquartered in Cuijk, the Netherlands, manufactures advanced thermal management solutions that are crucial to the global semiconductor industry as well as to the opto-electronic and photonics sectors.

As a supplier of high-end components for these industries, Mintres B.V. specializes in the development and in-house production of custom submounts and heat spreaders for high-performance applications.

The ability of Mintres B.V. to manufacture tailored high-end components for a wide variety of products, with highly variable turnaround times, requires the highest degrees of flexibility in product design and manufacturing processes. The flexibility to adapt to customer requirements adds complexity to production planning, as different products may necessitate a different sequence of processing steps. The increased complexity of planning affects the task of allocating resources to work stations and of order sequence scheduling. Moreover, Mintres B.V. operates in a constantly evolving environment, necessitating frequent re-planning due to unforeseen disruptions such as equipment breakdowns, staff shortages, or urgent order modifications. This further complicates the high-dimensional optimization problem of production planning.

Currently, solving this optimization problem (i.e. planning and re-planning of orders) is done exclusively by hand. Due to the complexity of the task and the dynamic nature of production at Mintres B.V., the planning process is

time-consuming and often leads to not fully optimized production schedules, particularly in terms of punctuality, production volume, and efficiency.

Target

In a joint digitization project with Fraunhofer IPT and FIP-AM@UT, Mintres B.V. aims to develop an intelligent and collaborative order scheduling ERP-module that provides planners with suggestions for highly efficient and timely manufacturing order schedules. Furthermore, the planner must have the option of re-planning under changed conditions and to manually adjust individual orders. This module is designed to tackle the challenges of resource allocation and order scheduling by assisting the planner in creating more efficient schedules and responding more quickly to disruptions.

The module needs to optimize scheduling by considering multiple factors, including machine capacity, varying worker skill levels, availability, and unforeseen changes. These constraints further add complexity to the planning task.

By implementing an intelligent scheduling solution, manufacturers can reduce planning complexity, enhance production efficiency, and establish a scalable framework that adapts to evolving operational demands. Such an intelligent planning tool not only reduces planning efforts, but also improves resource utilization, reduces costs through bundling orders - where possible -, and identifies orders at high risk of delay. Consequently, an intelligent planning module provides a significant competitive advantage.

Approach and Collaboration

The intelligent planning module facilitates evolutionary algorithms that mimic natural evolutionary processes, improving solutions over successive generations. In several successive iterations, the algorithm generates a variety of different production program plans, evaluates them regarding a specific optimization target, e.g. punctuality and efficiency, and refines them so that an optimal production program is ultimately proposed to the planner.

The usability of the intelligent planning module is enhanced through the integration into the existing system landscape of Mintres B.V.. The model seamlessly integrates with the ERP system for easy use. This ensures that current open orders in the system are always considered for planning purposes.

Moreover, a key component of the intelligent planning module is its user interface, which presents the final schedule to the planner and visualizes crucial insights into this schedule, such as potential lateness or punctuality of each order.

Outlook

The intelligent planning module is the first step on the digitalization roadmap of Mintres B.V.. In the long term, Mintres B.V. aims to realize a digital and intelligent production utilizing a real-time-capable traceability system. The purpose of the traceability system is to precisely track orders and, consequently, to support the evolution of the production planning module. Additionally, it enables real-time monitoring of production through integrated dashboards.

Mintres B.V.'s strategy for digitizing their production responds to growing market demand for high-end components. The semiconductor industry in particular, with its evolving requirements for modern technologies such as AI, IoT and 5G, makes a faster and more flexible reaction an important competitive advantage.

CIRCULAR MANUFACTURING SYSTEMS PROGRAM (CMSP)

Powered by: **RegioDeal Twente**

The Fraunhofer Innovation Platform for Advanced Manufacturing at the University of Twente (FIP-AM@UT), in collaboration with the regional government and industry partners, has launched the Circular Manufacturing Systems Program (CMSP) to advance sustainable, automated, and efficient production processes. The program strengthens the high-tech manufacturing sector in the eastern Netherlands by promoting circularity across various industries, including energy storage and broader industrial applications.

CMSP focuses on optimising manufacturing through automation, material recovery, and modular product design, fostering collaboration between regional and international partners to drive sustainability and waste reduction. By integrating digital tools and innovative production techniques, the programme enhances efficiency, traceability, and resource management.

A key aspect of CMSP is industrial collaboration. Participating companies gain access to cutting-edge research, technological advancements, and cross-sector knowledge exchange.

Through demonstrators, pilot projects, and training initiatives, FIP-AM@UT ensures that innovations developed within the program are widely adopted, strengthening the region's manufacturing competitiveness and sustainability.

Supported by the RegioDeal Twente, with funding from the Province of Overijssel and the Dutch State, CMSP aims to position Twente as a European hub for advanced manufacturing. The programme stimulates economic growth, attracts talent, and encourages investment in sustainable technologies.

Rijksoverheid

provincie Overijssel

Twente Board

05_ ELECTRIC SUPERBIKE TWENTE

ElectroCycle
with Electric Superbike Twente

ElectroCycle is a collaboration between the University of Twente, through FIP-AM@UT, and Electric Superbike Twente, exploring new opportunities to **make motor racing more sustainable.** The project targets three key areas: lightweighting components, adopting sustainable materials, and advancing electrification. These efforts align with **UN SDG12 (Ensure sustainable consumption and production patterns**) and **SDG13 - Take urgent action to combat climate change and its impacts.**

Redesigning for Lightweight Performance

The first part focuses on the design and production of the swingarm, a critical and traditionally heavy structural part of the motorcycle. The current swingarm design will be refined using topology optimization, a method that removes unnecessary material while maintaining strength, resulting in a lighter and more efficient structure. The improved structure can bear the applied load cases with the same safety factor. Production will be carried out through additive manufacturing processes such asby Powder Bed Fusion printing technology, which allows for the creation of complex shapes that would be challenging to achieve with conventional manufacturing. The result of this work will be a functional, lightweight swingarm that is validated for racing.

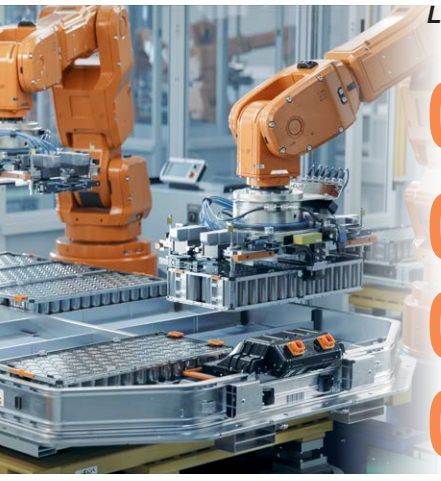
Sustainable Materials for the Tank Cover

The second of these project areas revolves around the design of a mold for the bike's tank cover. In particular, flax fibers will be used to reinforce the part, contributing to a more sustainable choice of materials. Manufacturing the tank cover can introduce challenges in mold design and manufacturing, which are addressed in this project.

Enhancing Electrical Performance

The final area of development focuses on improving the design of the battery connection system, an important step towards further electrification in motor racing. This includes engineering the connector system for efficiency, reliability, and safety in high-power applications. The work also involves designing and fabricating tooling for forming metal components of the connectors, using the 3D printing and CNC machining capabilities at the AMC to produce key tools such as punches and dies.

Together, these work packages combine lightweight design, sustainable materials, and energy-efficient electrical systems, driven by close collaboration between FIP-AM@UT and Electric Superbike Twente to help shape a more sustainable future for motor racing.



Learn more about other CMSP projects on the AMC NU section from InnovatieNU 14th edition!

01_ BattInnovate *with STERN Technologies*

02_ ReLAB *with Riwald Recycling*

03_ ExtraCycles *with Benchmark Electronics*

04_ MoCoSo *with Beckhoff and IMS*

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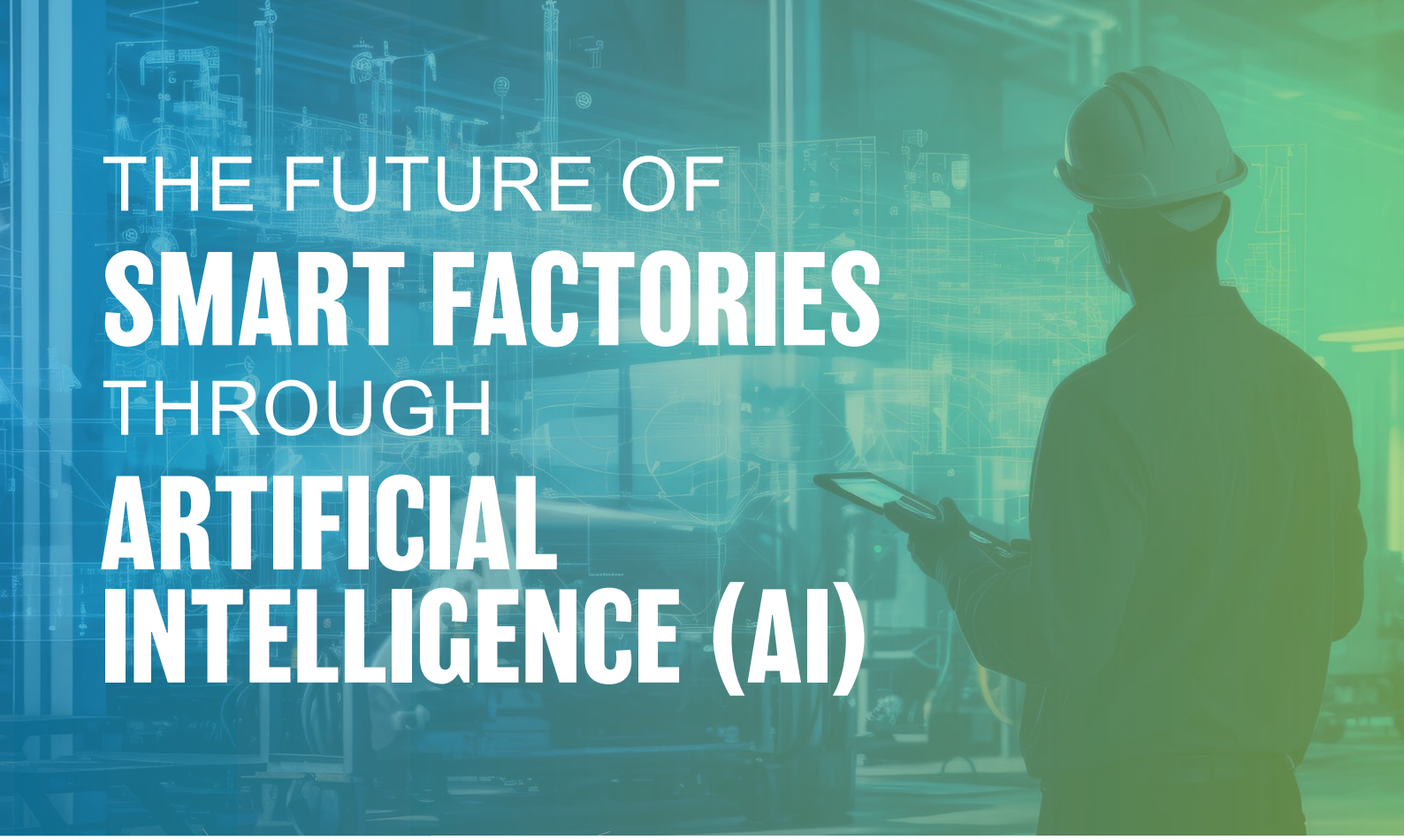

THE FUTURE OF SMART FACTORIES THROUGH ARTIFICIAL INTELLIGENCE (AI)

Limis

In the rapidly changing world of manufacturing, artificial intelligence (AI) is no longer just a technological trend, but an essential force that helps companies stay competitive. The question is no longer whether AI will change the future of manufacturing, but how fast it will bring that change. From predictive maintenance to autonomous quality control; AI is having an unprecedented impact on the way we manufacture, the efficiency we achieve and the innovation that becomes possible. In this article, Limis shares their insights on the impact of AI on the manufacturing industry and why these developments are crucial for the future.

Predictive Maintenance: Efficiency Through Smart Technology

One of the most notable ways AI is affecting manufacturing is through the introduction of predictive maintenance. Traditionally, machine maintenance depended on a fixed schedule or when machines actually broke down. This often led to downtime, unforeseen costs and delays in production.

With AI, manufacturers can now collect real-time data on the health status of machines and equipment. By using sensors and data analysis, AI can predict when a machine is likely to fail, even before the problem occurs. This technology reduces unexpected downtime and optimises machine life, resulting in lower costs and higher production efficiency.

For companies like Limis, focused on production planning and optimisation, this represents a big step forward. In the future, our planning software will start using AI-driven insights, allowing us to adjust production schedules based on real-time machine performance. This will allow companies to design their production processes even more flexibly and efficiently, which is essential for the future of the industry.

Smart Factories: Automation and Integration of Systems

The smart factory is another area where AI is making its mark. Here, machines, robots, and systems are seamlessly

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connected through the internet and AI-driven algorithms. This enables factories to communicate and operate independently, without constant human intervention.

At Limis, we are increasingly seeing how AI improves collaboration between systems. For example, AI can automatically plan orders based on available capacity, material requirements and delivery times, without the need for a planner to manually intervene. This ensures faster and more accurate production planning and reduces the risk of errors.

In the future, we will see more and more autonomous systems that not only control production, but also make decisions based on defined parameters, such as capacity, demand and material availability. This offers significant efficiency gains and enables companies to react quickly to changing market conditions.

Autonomous Quality Control: Increased Precision and Reliability

In traditional quality control, people perform inspections and collect data manually. This can be time-consuming and increase the risk of human error. AI can change this by using image recognition technology and advanced sensors that continuously monitor product quality during the production process.

For example, AI can automatically detect defects in manufactured parts and classify them according to their severity. This technology makes it possible to identify problems at an early stage, significantly reducing the number of defects in the final product. Moreover, AI allows companies to track quality scores in real-time, ensuring continuous improvement and reliable product quality.

At Limis, we see how companies can integrate autonomous quality control into their production planning, not only improving efficiency but also increasing the reliability of their products. In an industry where quality is crucial, this is a huge advance.

The Importance of AI for the Future of Manufacturing

The future of manufacturing is not only digital, but also AI-driven. Technology is changing not only how we produce, but also how we plan, design, and ensure quality. For companies that want to compete in a rapidly changing market, it is essential to embrace AI and integrate its benefits into their manufacturing processes.

At Limis, we believe AI-driven planning and optimisation are key for companies looking to improve their efficiency and flexibility. Our scheduling software uses real-time data and AI to optimise production processes, enabling companies to respond faster and more efficiently to changes in demand, capacity and other contingencies.

Integrating AI is an investment in the future that not only increases productivity, but also ensures a sustainable and innovative production process. Companies that embrace this technology will be better prepared to meet the challenges of the future and stay ahead of their competitors.

The Role of AI in the Future of Manufacturing

Artificial intelligence has the potential to transform manufacturing by increasing efficiency, improving precision and driving innovation. From predictive maintenance to autonomous quality control; AI provides powerful tools for manufacturers to stay competitive in an ever faster-changing industry. At Limis, we see the huge impact this technology is already having, and we believe AI is the key to a smart, efficient and competitive manufacturing environment. It is time to embrace AI and take advantage of the benefits it offers for the future of manufacturing.

“Integrating AI is an investment in the future that not only increases productivity, but also ensures a sustainable and innovative production process.”

STEP BY STEP TO THE AI SUMMIT

DARE TO THINK BIG, TAKE SMALL STEPS, BUT ABOVE ALL: BEGIN!

AIC4NL

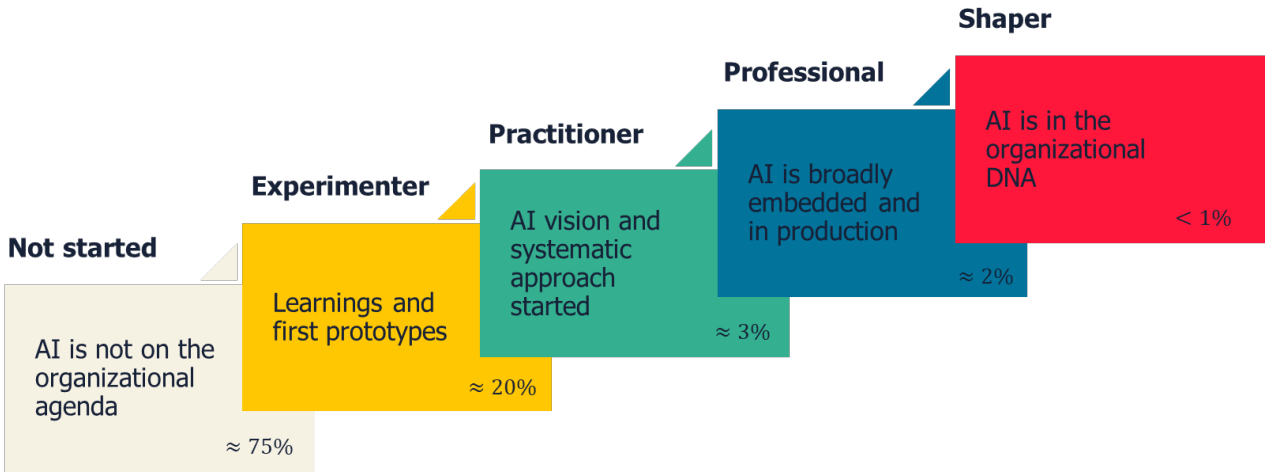
AI in the Industry

In recent years, artificial intelligence has experienced unprecedented growth worldwide. Also in the Netherlands, the technology is already widely used. According to the AI Monitor 2024 by CBS, 22 percent of Dutch companies with 10 or more employees use AI technologies – an increase of almost 9 percent compared to the previous year. This strong growth illustrates the increasing recognition of AI's potential, but at the same time hides a challenge: although almost all companies want to do "something" with AI, only a small part considers themselves ready for its implementation. Why is this the case? And more importantly: how can your company bridge this gap?

The Gap Between Potential and Practice

The technology is not the issue. Machine learning is transforming maintenance from reactive to predictive. Quality control is evolving from manual inspection to intelligent recognition systems that detect anomalies which escape the human eye. And through Agentic AI, supply chains are changing into dynamic processes where factors such as price, delivery date, and changing market conditions are managed in real-time. So the technology certainly isn't standing in the way – quite the contrary – it's entirely ready. Yet there remains a substantial difference between what's possible and the daily reality in most factories.

If we were to place all organizations on an AI ladder, we would see that the majority still stand below the first rung and haven't yet started with AI



integration. For this group, AI is not on the strategic agenda, putting them at significant risk of losing market relevance. One step higher are the organizations that have begun with several AI use cases. These organizations have developed initial prototypes and gathered lessons learned, with applications primarily focused on increasing productivity through task automation — such as smarter searches, faster customer processing, or data usage for maintenance and quality control. However, many of these remain stuck at the proof-of-concept level without further scaling. Higher up the ladder, we see organizations that have formulated an AI vision, realized its embedding, and fully incorporated AI into the DNA of the organization. These three rungs together comprise only 5% of all organizations in the Netherlands.

That less than 25% of organizations have taken a first step is understandable – for many, it's unclear where to begin, which AI applications will actually add value, and how AI can be integrated into existing processes. This requires not only a technical infrastructure but also a corporate culture that is open to discovering the possibilities of AI. This culture is often already present in some form, in the willingness and interest of employees.

Employees are Ready – Is Management Too?

Recent research from McKinsey & Company's 'Superagency in the Workplace' shows that almost all employees (94 percent) have some familiarity with generative AI tools, while C-level consistently underestimate AI integration within their organizations. Where managers suspect that only four percent of employees utilize AI for their daily activities, employees argue that this percentage is three times higher. This discrepancy also manifests in future expectations: management anticipates that only 20 percent of

staff will integrate AI into daily tasks within a year, while almost half (47%) of employees themselves express this intention.

The figures from this research give a clear signal: the brake on AI adoption does not lie with employees, but rather with hesitant management that underestimates their teams' AI readiness. The popularity of ChatGPT and other generative AI tools has already created a natural openness. Employees who have gained experience with these accessible AI applications at home or in the office are potentially much more receptive to further innovation. Their first positive experiences with text generators may make the step toward machine learning for process optimization or deep learning for complex analyses much smaller and less threatening than thought.

Although most respondents in the McKinsey research come from the US, we also see widespread use of ChatGPT and other generative AI tools in the Netherlands. Here too, familiarity with AI and acceptance of AI is growing.

The Way Forward

With employees who are willing and a technology that is ready, the challenge seems to lie primarily with the vision and ambition behind AI implementation and the courage to take a step on the AI ladder. To facilitate this transition, a shift in thinking is necessary: from fear of uncertainty to envisioning possibilities. AI is still too often seen as a technology that "comes in addition" rather than as a catalyst for transformation. The challenge here is not only to implement quickly but to find the right balance between speed and safety, between incremental improvements and innovation.

Organizations are not alone in this search for balance. Various AI assessments are available and trainings can be followed – for both employees and employers. The AI Coalition for the Netherlands (AIC4NL) also offers support programs to stimulate the use of AI. These include learning from and with each other, AI investment programs for SMEs and start-ups, talent training, the development of AI prototypes, and scaling up successful initiatives.

Despite this available support, successful implementation requires primarily courage: the courage to ask big questions, such as how traditional cost centres can be transformed into value-driven functions, or how competitive advantage can be gained by strategically investing in AI. Because although support programs can facilitate technical implementation, finding the right balance for your specific organization remains a crucial

> **"The highest price of AI is not the investment you make today, but the market position you lose tomorrow by doing nothing."**

> **The time to take action is now. Not tomorrow, not next year, but today.**

challenge. After all, the highest price of AI is not the investment you make today, but the market position you lose tomorrow by doing nothing.

The Call to Action: Begin!

All ingredients for success are present. The technology is ready to be implemented and is developing at a rapid pace. Employees are more willing to apply AI than thought. Managers have more space than they realize to deploy AI in the workplace and on the production floor.

So start by thinking big: determine the organization's vision regarding the use and deployment of AI and create a roadmap. Don't blindly embrace AI, don't fearfully reject it, but explore it strategically. Ensure everyone is on the same page and discover what you can learn from other companies. Then begin with focused, small projects that solve specific challenges. Pick low-hanging fruits: what can you already improve with (generative) AI? Additionally, based on your strategic AI roadmap, consider what next steps you want to take toward the 'AI point on the horizon,' and what technical infrastructure you want to work toward to be able to fully utilize the possibilities of AI.

The time to take action is now. Not tomorrow, not next year, but today. Because while you hesitate, your competitor may already be taking the next step on the AI ladder. The choice is yours. Dare to think big, start small, but above all: begin. ■

Machine vision for battery inspection at the Advanced Manufacturing Center, Enschede. For more information and related projects, visit fip.utwente.nl

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transAI

transAI

Get a grip on your production

STEP INTO THE WORLD OF THE DIGITAL MANUFACTURING INDUSTRY.

Imagine a bustling factory floor where machines operate at full capacity, operators closely monitor quality, and planners strive to maintain oversight.

Yet behind the scenes, a multitude of challenges exist: machines operate with different software versions, data entry is manual, and disparate systems fail to communicate effectively. Operators search for the right settings and drawings, planners grapple with fragmented data, and no one knows exactly where an order stands. Valuable time slips away, and errors inevitably creep in.

To streamline the production process, it's crucial to digitally connect machines, systems, and personnel within the factory. This incremental digital integration gives you increasingly precise control over your production. To facilitate this transformation, TransAI has developed an intelligent platform.

Innovating European Manufacturing from Twente

TransAI was established in partnership with several manufacturing companies aiming to digitize and automate complex production environments. This collaboration operates as a cooperative, allowing other manufacturers to join, truly embodying their slogan: “For and by the manufacturing industry.”

TransAI actively collaborates with regional partners such as NoveIT, the Fraunhofer Innovation Platform, and OostNL. Already, six factories have integrated with the transAI platform. From Twente, we’re building a European platform designed to innovate manufacturing industries and strengthen international competitiveness.

From Disconnected Systems to a Smart Platform

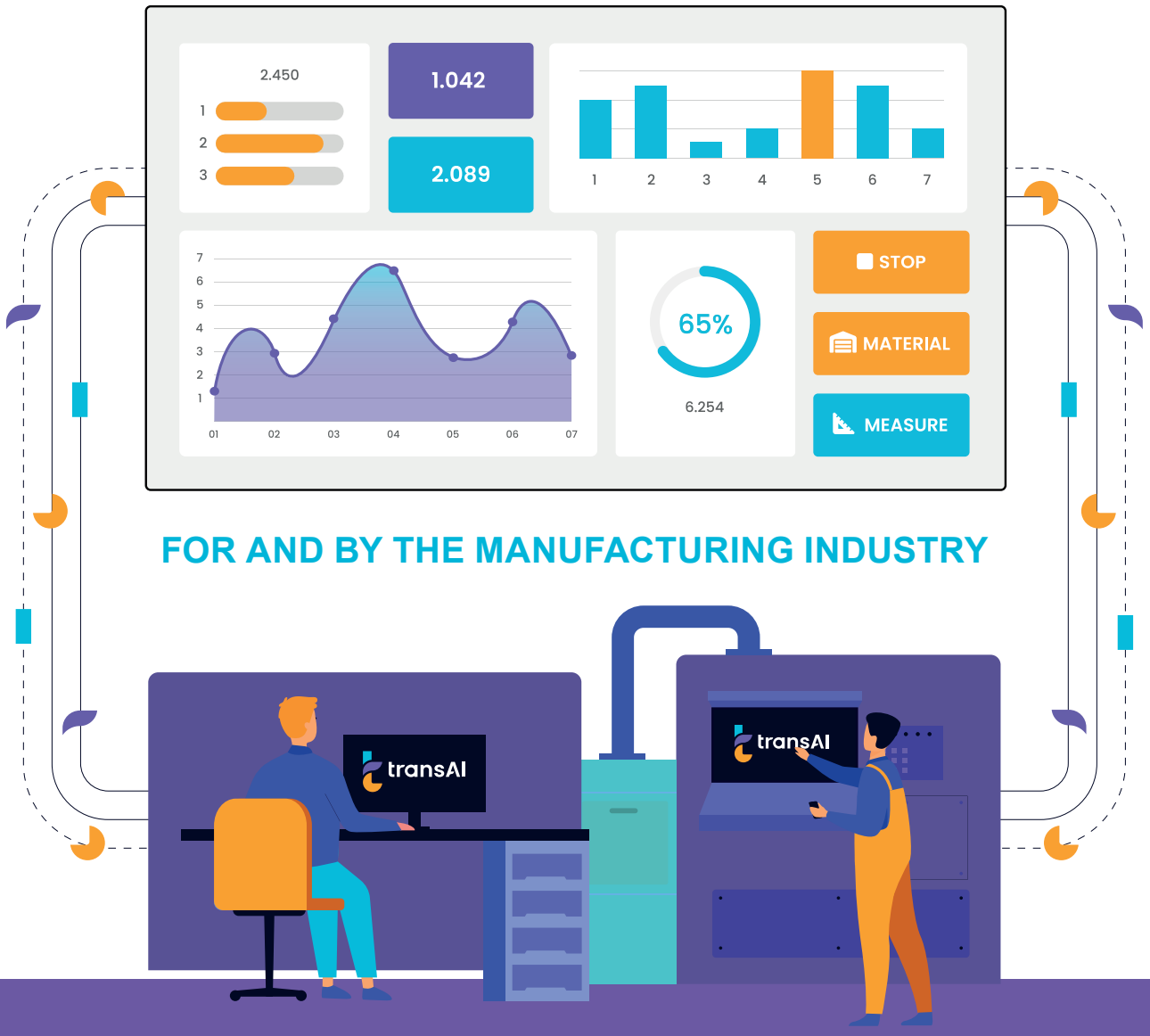
At transAI, we’ve observed that many manufacturing companies struggle with scattered data and isolated software solutions. ERP systems, machines, and sensors typically function independently, with inadequate inter-system communication.

Each department relies on its specialized applications: production data logged in one system, quality metrics in another, and energy consumption data elsewhere. Though logical, these systems depend on each other’s information to function optimally.

This challenge spurred the creation of the transAI platform. By automating data exchanges and enriching existing applications with accurate information, the platform enables greater control of production without custom software or complex IT projects.

The transAI platform integrates all machines and applications into a unified, real-time ecosystem. Information becomes readily accessible, displayed clearly in dashboards rather than on paper forms. Employees can quickly find relevant data and initiate actions directly.

For instance, the platform can enhance the traceability of materials and other production resources, streamlining processes considerably.



Beyond Dashboards: Immediate Action Across All Systems

TransAI doesn't merely collect data for dashboard presentations—it actively interacts with machines and applications.

Changes initiated through the platform are instantly propagated across connected systems within your company. By creating automated workflows, you can optimize machine performance, update ERP systems instantly, or even manage energy usage directly tied to production planning.

These workflows are adaptable and easily modifiable, enabling progressively extensive automation throughout your factory. The platform grows and evolves alongside your needs.

Human and Machine: One Team

At transAI, digitalisation isn't the goal itself; it's a means to empower people to work smarter. Our platform eliminates repetitive tasks, allowing operators and engineers to focus on higher-value activities.

Companies adopting this data-driven approach reduce errors, accelerate innovation, and mitigate dependence on scarce expertise, making their production robust and future-proof.

Real-World Impact: transAI in Action

The transAI platform is already actively implemented in various production environments. Together with our partners, we continuously test and refine the solution for maximum operational impact.

The results speak volumes: *"TransAI enabled us to transition to a fully digitized production environment,"* enthuses Arjan from Betech Group, adding, *"Our machine output increased by 12% thanks to transAI."* Arnold from Maathof Group shares his experience: *"Not only did transAI significantly enhance our production processes and eliminate paperwork, but it also vastly improved our time tracking."*

At transAI, digitalisation isn't the goal itself; it's a means to empower people to work smarter. Our platform eliminates repetitive tasks, allowing operators and engineers to focus on higher-value activities.

AI: The Next Step—Chatting with Your Factory

How much downtime occurred this month?

What's the energy usage per production line?

Which machines underperform?

These are questions easily answered by the next phase of understanding your production: an AI chatbot.

Instead of combing through reports, ask straightforward questions and receive real-time insights and actionable recommendations directly from the system. This accessible application of AI swiftly and intelligently integrates onto your factory floor.

Safe and Secure: ISO 27001 Certified

At transAI, data security is paramount. We are ISO 27001-certified, meeting rigorous international standards for information security. From encrypted data streams to controlled user access, we ensure customer data is always handled securely and carefully, providing a robust, smart, efficient, and secure platform. ■

Smartly Engineered | transAI

Choosing transAI means selecting a simple, intelligent, and flexible solution built for the future.

Want to learn more?
Visit www.transai.com or contact us at info@transai.com

ARE WE THERE YET?

*STEPS TO TAKE FOR **ADOPTION OF AI** IN MANUFACTURING INDUSTRY*

Manufacturing industries have come a long way by transitioning from purely analog-style production to digitally connected systems. They acquired many in-depth insights in their respective processes. However, the journey of digitization in the manufacturing sector is far from over. Industry 4.0 and 5.0 frameworks present us with the underlying intermediate steps where AI is one of them. However, realizing them may be more challenging for some than others. Note that AI is not an end goal by itself, yet it can serve as an essential support, both as an integral tool for enabling this change and as a technology for specific applications. Examples include predictive maintenance, quality assurance and process enhancements. At our research group Ambient Intelligence, we strive to enhance the uptake of AI by applying insights from fundamental research to real-life use cases in industry. So, what we observe is that we are not yet there: additional steps are required for successful adoption of AI in manufacturing. In this article, we reflect on our observations and provide handholds for more effective utilization and embedding of AI in manufacturing industries.

AI has been around for over 70 years, with a steep rise in interest since 2010, especially with deep learning entering the field. More recently, since foundation models became available to the larger public through services like ChatGPT and DeepSeek, the interest in AI has increased exponentially. One striking thing about AI in general is the perception of what it is or could do. This influences one's expectations about such technology leading to unprecedented hype and fear of 'missing the boat'.[1] Mainly, because of not being able to keep up with technological growth and competition, due to lack of knowledge or personnel. Through our projects, we try to dampen such sentiments when we discuss matters with manufacturing companies. Yes, much is possible with AI, but what is more important is figuring out what could be enhanced in contemporary manufacturing processes – AI is a tool, not an end goal. However, there are many facets to manufacturing processes that can benefit from AI, such as optimizing planning, modelling processes and aiding digital twins for improved design and efficiency, predicting product quality and maintenance needs, and automating repetitive tasks.[2]

In our research projects, we have worked together with companies at various stages of digitization in their manufacturing processes. From lean assembly straits at Scania Production[3] and necessity for digital infrastructure at SMEs[4] to high-tech and high-volume productions at ASML and Canon Production Printing[5]. There are challenges all along the way. One main challenge of AI is data: the availability of data, its quality, and how it is governed. Looking at quality assurance for products as an example, we see a dilemma in the manufacturing industry. In high-volume production, products cannot be thoroughly tested from a cost perspective; conversely, each defective product or process results in extra costs as well as damage to the manufacturer's reputation. Predictive modelling can help

assure the quality of products and thus reduce bottlenecks introduced by manual quality control. In essence, data related to manufacturing (used materials, system states) together with the manufacturing process (usage characteristics) can be utilized to develop passports on the quality of individual products.

However, for SMEs, this cannot be easily realized due to various limitations such as the availability of labelled data. Even if the company has all the process data available from raw material to the finished product and sale of the product, one cannot train a complete, predictive model since it is rarely known what the eventual product quality is. Furthermore, a central question is whether the data themselves are of sufficient quality to base a model on. For example, given only a few measurements on failed products, are these measurements trustworthy, and what is the quality of the model based on them? These challenges necessitate investigation into methods and techniques for predictive modelling of manufacturing processes. Moreover, this example exposes that AI adoption is not a single-step process. Creating models through AI based on data requires data of sufficient quality: these need to be gathered and stored, which in turn require processes related to connectivity, for example, through IoT-based solutions.

Methods for data acquisition and IoT have matured over time, and these frameworks are standardized. However, deploying them in a manufacturing environment is beyond trivial.
In our experience, the hindrance can be as simple as access to the existing network infrastructure. Certain B2B service agreements require a higher level of security before a new device is introduced into the network. Advances in federated learning allow data to remain on-premise of companies, without the data being shared externally. This provides a promise of data protection, yet even access to models trained on federated data can be re-engineered to pinpoint certain data attributes to one data source, thus a vulnerability and security threat. Such constraints on data sharing are another concern that hinders wider adoption.

For adopting AI in manufacturing, we provide four guidelines based on project experiences and scientific literature.

1.First and foremost: start with a goal. This can already be challenging, especially because it needs to be sufficiently specific to allow for actual usage and implementation of AI. This is a process of discovering and refining a problem statement.

2. Second, and supporting the first guideline: adopt a methodology.
At our group Ambient Intelligence, we use CRISP-DM as a standard for our data- and AI-related projects. A recent extension on this is called CRISP-DMME: the CRoss-Industry Standard Process for Data Mining Methodology for Engineers. It provides an overview of specific phases related to handling data and AI, with additional emphasis on engineering processes.

3. Third: determine how AI could be embedded in your organization, especially focusing on how it influences the role of people in the processes. Adopting AI successfully requires personnel to familiarize with it and have sufficient AI literacy to be aware of its possibilities, shortcomings, and how they and the company can best benefit from it.

4. And finally, the fourth: join forces.
Connect to existing and shape new initiatives through projects or learning communities, to experiment and learn from other companies and knowledge institutes.

For AI in manufacturing, it pays off to take a step back and gain an overview of the entirety of the manufacturing process. Defining the challenges and possible shortcomings of the existing situation can reveal where action needs to be taken. With best practices and practical examples aplenty, the need to pause before taking steps in this journey is almost minimal. Set a goal, use a method, and start experimenting with AI. ■

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SHAPING THE FUTURE OF RESEARCH IN THE AI ERA

What comes to mind when you think about research? For decades, it's been a journey powered by passion, patience, and persistence; with researchers filtering through journals, crunching data, and slowly building knowledge brick by brick. But today, that journey is rapidly evolving.

We are standing at the crossroads of a major transformation, where artificial intelligence (AI) is not just a tool; it's becoming a collaborator. So how exactly did we get here? How did research look before AI, how has it changed, and what lies ahead?

Before AI: The Era of Manual Exploration

Let's rewind. Imagine spending days, even weeks, in a library just to gather enough sources for a literature review. No smart search engines, no auto-suggestions, and certainly no instant summaries. Every citation was manually tracked. Every dataset was collected piece by piece.

Back then, formulating a hypothesis relied heavily on your own memory, mentorship, and a lot of reading. Collaborations were mostly limited to who you knew and could physically meet or write to. And publishing? A marathon of drafts, snail mail reviews, and editorial cycles.

Yes, this old-school model nurtured depth and critical thinking. But it was slow, and often inaccessible to those without institutional support. Many bright minds never got the chance to shine, simply because the tools and access weren't there.

Enter AI: Research, Accelerated and Amplified

Now, fast forward to the present. Can you imagine scanning millions of academic papers in seconds to find patterns or gaps in knowledge? AI can.

Tools like natural language processing (NLP) models assist in summarizing articles, suggesting references, and even drafting early versions of your paper. Machine learning algorithms spot complex trends in massive datasets; from predicting protein structures to modeling climate change.

But AI isn't just speeding things up; it's leveling the playing field. Open-source platforms, cloud tools, and AI-assisted processing allow researchers from less-funded institutions to access world-class capabilities.

It also bridges disciplines. Have you ever struggled to understand jargon from a different field? AI translation and simplification tools are making cross-disciplinary collaboration smoother and more inclusive.
Of course, these benefits come with new responsibilities. We're now navigating questions around algorithmic bias, data privacy, and the ethics of automated authorship. But the trajectory is clear: AI is here to stay, and it's reshaping how we do research.

The Future: Intelligent, Predictive, and Human-Centered

What if, before even starting a project, you could forecast whether it's likely to succeed? What if AI could tell you not just if your idea is new, but whether it could have real-world impact or even commercial value?

Welcome to the future of research. Here, AI doesn't just help analyze data; it helps us design better research from the outset. It assists with proposal writing, assesses risk and reward, and connects you with the right people at the right time.

Imagine collaborative platforms where researchers, funders, and industry partners interact in real-time. No more silos, no more missed opportunities.

Education will evolve too. Tomorrow's researchers will need to be fluent not just in their field, but in AI literacy; how to evaluate models, understand biases, and use tools responsibly.

And while automation will handle the repetitive tasks, the human spark 'our creativity, ethics, and imagination' will matter more than ever.

AI's Limitations and challenges

Daniel Dennett (March 28, 1942 – April 19, 2024), the influential philosopher, spoke with the BBC before his death about his lifelong effort to understand the human experience and the reason for his concern about the emerging risks of artificial intelligence.

His warning was not about a superintelligence taking over power, but rather about a threat that he believed still poses an existential danger to civilization; one rooted in the vulnerability of human nature.

He said, "If we turn this extraordinary technology, which we have for knowledge, into a weapon for misinformation, we'll be in big trouble." Why? "Because we no longer know what we know; we don't know who to trust; we don't know whether we're informed or misled. We may become either paranoid and overly suspicious, or simply indifferent and inert. Both are extremely dangerous paths before us."

While AI brings many benefits to research, it also presents several important challenges. One key concern is privacy and idea protection, as AI tools often require access to large datasets. If not managed carefully, this could lead to private research ideas or valuable content being exposed or

> **If we turn this extraordinary technology, which we have for knowledge, into a weapon for misinformation, we'll be in big trouble.**
>
> *- Daniel Dennett, American Philosopher*

misused without permission. Another challenge is the lack of human touch; while AI can identify patterns and offer suggestions, it doesn't grasp meaning, ethics, or creativity the way humans do, which can result in misleading or impractical outcomes when over-relied upon. Finally, trust and transparency remain critical issues; AI systems often don't explain how they reach their conclusions, making it difficult for researchers to fully trust or validate results, especially in high-stakes projects.

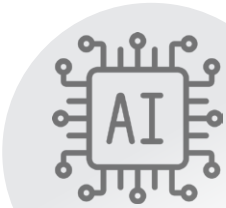
To mitigate these issues, researchers and developers can adopt several strategies. Ensuring strong data privacy measures, such as encryption and strict access controls, can help protect sensitive research information. Additionally, using AI as a supportive tool rather than a replacement for human judgment allows for a balance between automation and human insight, preserving ethical and creative perspectives. Promoting transparency through explainable AI models can also build trust, as it enables users to understand how decisions are made. Finally, establishing clear guidelines and ethical frameworks for AI use in research can help prevent misuse and ensure responsible development and application.

SCIONS

SCIONS: Predictive Collaboration for Smarter Research

Recognizing the rapid evolution of research in the AI era along its constraints and challenges, has been part of the development of research support platforms, like the SCIONS, to address how can we ensure that research ideas are both innovative and commercially viable before major resources are invested.

SCIONS is an online platform built to support the future of research. At its core, it connects researchers across disciplines and geographies, creating a vibrant community where ideas can be shared, refined, and tested in a collaborative environment. SCIONS' unique approach involves the use of AI to predict the potential of a research idea even before it is launched as a full project. The platform accomplishes this by paying attention to key areas:



AI structure

Using a combination of machine learning, market data analysis, and user-inputted technical content, to evaluate the commercialization potential of early-stage research ideas. Thus identifying similar past efforts, assess market trends, and even suggest adjustments to improve an idea's impact and feasibility. This approach helps researchers make more informed decisions, allows institutions to prioritize high-impact proposals, and supports funding bodies in evaluating ideas based on real-world potential.

Human collaboration

The platform also makes use of tiered user roles; connecting junior researchers, industry partners, and investors in a space where mentorship and feedback are

While AI brings many benefits to research, it also presents several important challenges. One key concern is privacy and idea protection, as AI tools often require access to large datasets.

built into the lifecycle of an idea. This enables peer feedback, expert reviews, and open discussions alongside AI generated analysis that lead to research ideas that are relevant, feasible, and ethically sound.

Enhanced insights

Through predictive analytics and providing a collaborative ecosystem, it empowers researchers to innovate with confidence and clarity in a world that increasingly values outcomes and impact.

Ethical considerations

To ensure secure, ethical, and meaningful collaboration a key feature is the use of online Non-Disclosure Agreements (NDAs), which must be signed before any sensitive idea is shared. This creates a protected environment where researchers can confidently explore their ideas without fear of misuse or premature exposure.

Transparency and trust

By providing every predictive insight with clear justifications and suggestions for human review.

By combining the analytical power of AI with the wisdom and ethics of human collaboration, SCIONS ensures that technology enhances the research journey. It creates a space where innovation is secure, thoughtful, and inclusive.

Research, Reinvented

The integration of AI into research represents more than just a technological advancement; it signifies a fundamental cultural shift. We are entering an era where research ideas are assessed not only for their academic rigor but also for their real-world applicability and societal impact. Platforms like SCIONS are at the forefront of this transformation, enabling researchers to predict, prepare, and progress with greater clarity and confidence.

By embracing AI-powered tools and nurturing platforms that promote early-stage evaluation and collaboration, the research community can unlock unique levels of innovation, inclusivity, and excellence. This is not about replacing the researcher, but about enhancing the research journey.

The future of research will be defined by how we leverage AI; not simply to automate tasks, but to elevate the very qualities that make research meaningful. With the right mindset and digital infrastructure, the AI era promises a research landscape that is not only faster and more efficient, but profoundly more impactful.

So, what role will you play in this AI-powered research era? Will you adapt, collaborate, and lead? The next frontier of discovery awaits and it's smarter, more inclusive, and more exciting than ever. ■

To know more about SCIONS, contact:

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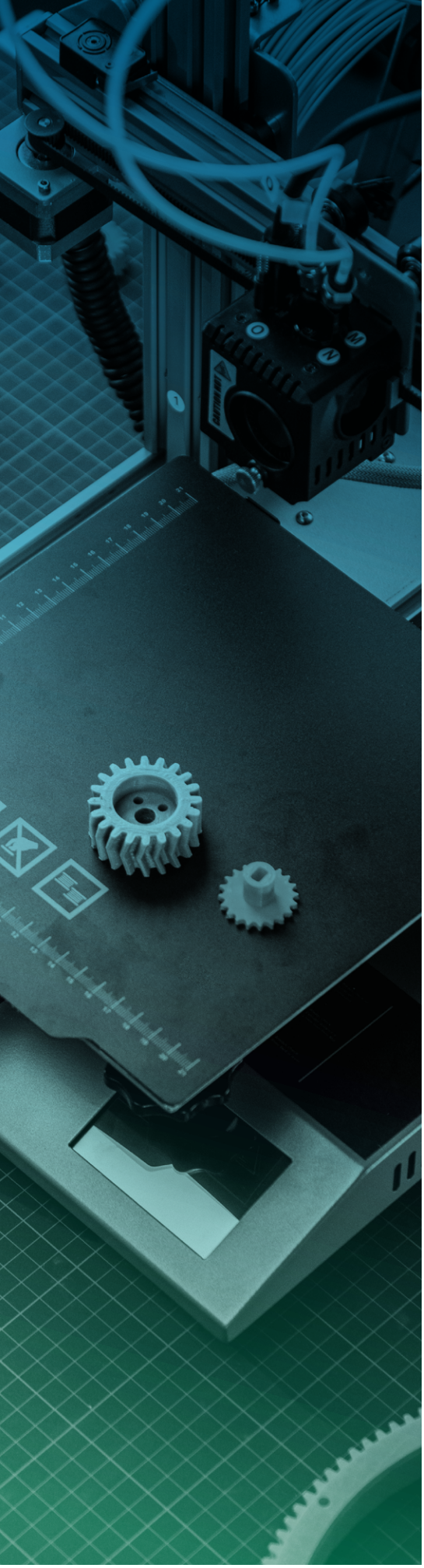

DETECTING 3D PRINTING FAILURES WITH AI AND COMPUTER VISION

Additive Manufacturing (AM), commonly known as 3D printing, has rapidly grown in popularity, both for prototyping and manufacturing final products. Among AM techniques, Fused Deposition Modeling (FDM) is the most widespread, thanks to its ease of use and cost-effectiveness, as well as support for a wide range of materials. However, FDM remains imperfect, commonly facing defects that affect print quality or make the final product completely unusable.

Motivated by these recurring issues in FDM, I conducted this research as part of my graduation project for the MSc in Computer Science at the University of Twente. The project took place from September 2024 to April 2025 at the Fraunhofer Innovation Platform for Advanced Manufacturing at the University of Twente. I carried out the work under the supervision of Dr. Ir. Alex Chiumento, Prof. Dr. Mariëlle I.A. Stoelinga, and Ir. Reinier Stribos. Their guidance and expertise helped me in shaping a focused investigation into real-time defect detection using AI and computer vision.

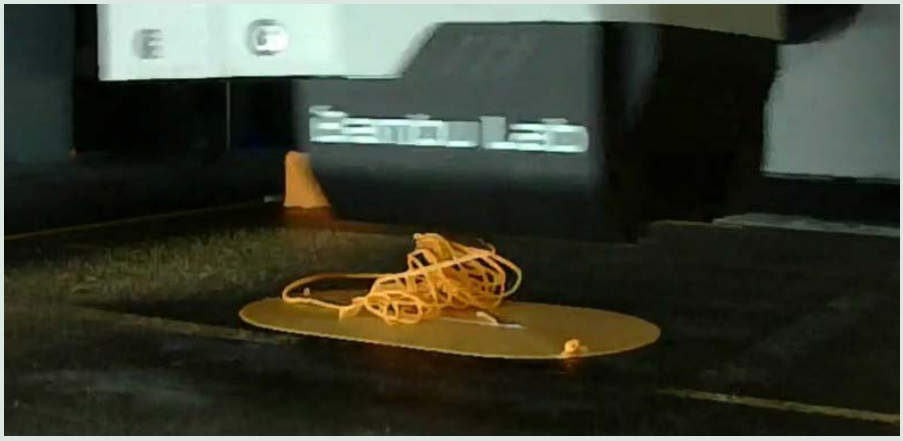

Figure 1. Example of a spaghetti defect formed after the printed object detached from the print bed.

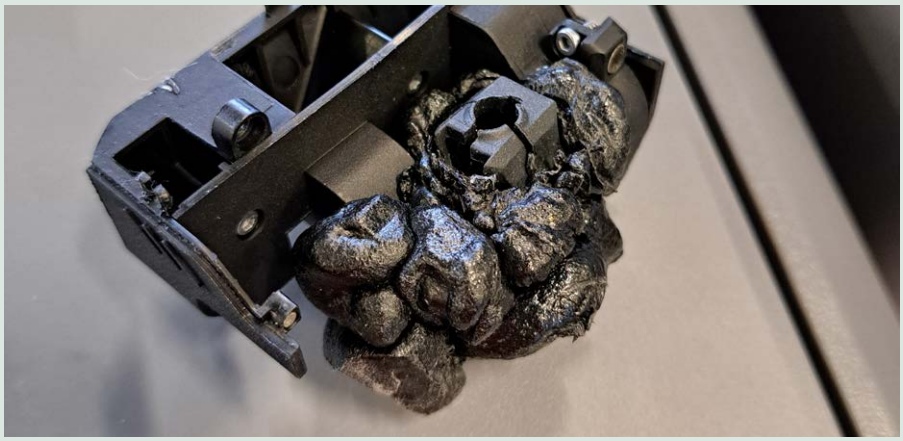

Figure 2. A destructive "blob of death" formed during a failed print.

Figure 3. YOLO11 output, showing two detected spaghetti defects.

One very common error is the **spaghetti defect** (see Figure 1). This failure occurs when printed parts detach mid-process, causing semi-liquid filament to be extruded into the air instead of attaching to the previous layer. This results in a mess of curled-up filament resembling spaghetti, hence the name. If the printer is not stopped, this mess can turn into a "blob of death", where built-up filament forms around the print head, sometimes damaging hardware and potentially requiring costly repairs (see Figure 2).

Smart Detection with AI (YOLO11)

Catching a defect early is the best way to prevent wasted filament, time, and possible damage to hardware. Traditional methods rely on sensor data or fixed thresholds, but modern solutions make use of AI and computer vision.

By using a camera with a computer vision algorithm, 3D printers can identify defects as they occur and respond in real time, without the need for human intervention. In my research project, I explored spaghetti defect detection by using one of the most advanced real-time detection algorithms currently available: YOLO11. Additionally, an experiment was conducted using a Low-Light Image Enhancement (LLIE) algorithm to see if it impacted detection performance in low-contrast scenarios, such as when using black filament.

You Only Look Once (YOLO) is a state-of-the-art object detection algorithm, known for its high speed and precision. It can not only determine whether an image contains a spaghetti defect, but also where that defect is present. Figure 3 shows YOLO11 detecting multiple spaghetti defects.

> **This work introduced the Print Failure Stopping Metric (PFSM), providing a way to show how a detection system would behave during an actual print. The PFSM simulates what would happen if a printer were to stop after a number of consecutive frames with detected defects.**

The Print Failure Stopping Metric

Traditional evaluation metrics, such as accuracy and F1-score (a measure of predictive performance), show how well the model performs on individual image frames. This is good for evaluating overall performance, but it does not consider the entire printing process. For this reason, this work introduced the Print Failure Stopping Metric (PFSM), providing a way to show how a detection system would behave during an actual print.

The PFSM simulates what would happen if a printer were to stop after a number of consecutive frames with detected defects. For example, the printer might be set to stop after three consecutive frames containing detected spaghetti defects. By comparing whether the printer ***would have stopped*** and ***should have stopped***, the PFSM provides an easy way to analyze how the system would behave in practice.

Besides simulating real-world performance, the PFSM helps fine-tune the trade-off between stopping unnecessarily – false positives (FPs) – and failing to stop when a defect occurs – false negatives (FNs). Higher stopping thresholds reduce FPs, but might miss real defects. In contrast, lower thresholds catch more defects, but may stop the print when no real issue occurs. By analyzing the system's behaviour across different stopping thresholds, the optimal balance can be achieved.

Results

To evaluate the detection performance, the YOLO11-based approach was compared against the open-source Obico implementation, which is built using an older YOLOv2 model (https://github.com/TheSpaghettiDetective/obico-server). The results showed that YOLO11 outperformed Obico across all tests:

+41.7%

F1-score on prints with coloured filament

+20%

F1-score on black filament (low-contrast)

+17.5%

F1-score on an external dataset

These improvements demonstrate that YOLO11 has strong generalizability and robustness, not only performing better in low-contrast scenarios, but also effectively detecting defects in unseen environments.

Using the PFSM metric, a major improvement in real-world stopping behaviour was observed. The YOLO11 model obtained significantly fewer false positives, while correctly detecting more defects. This means less material waste and hardware damage while having fewer unnecessary stops.

Lastly, the effect of LLIE was tested on the low-contrast dataset. However, no improvement was observed. This highlights that YOLO11 already handles such scenarios well, without the need of LLIE.

Looking ahead

This research shows that upgrading to the latest YOLO version can bring a significant performance increase to spaghetti defect detection in 3D printers, reducing wasted material and time. This performance increase can be seen not only in the dataset collected for this work, but also in unseen environments, demonstrating the model's generalizability and robustness.

In low-contrast environments, LLIE showed no significant improvements. However, alternative solutions to improve in this area should be explored. Depth-based imaging techniques, such as using LiDAR or stereo vision, could provide more reliable data for detection by capturing the three-dimensional structure, reducing dependence on two-dimensional image contrast.

My full thesis is available here: https://purl.utwente.nl/essays/106149

Leenheer IT

After finishing this research, I founded Leenheer IT, where I work as a consultant focused on applying machine learning to real-world problems. Whether it's using computer vision to detect 3D printing defects or exploring entirely different use cases, I enjoy finding practical ways to use modern AI.

If you are interested in integrating AI into your product or workflow, feel free to reach out. I am always open to discussing ideas and collaborations in applied AI and machine learning. You can contact me at ***bart@leenheer-it.nl***. ■

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Data Science Consultant,
Leenheer IT

HIGH-TECH LASER AND AI FOR INCREASED STEEL RECYCLING

TATA STEEL

Tata Steel Nederland, German and Austrian steel producers are co-innovating for more sustainable, energy-efficient steel production.

As the global demand for steel continues to grow, the pressure to make the steel sector more sustainable is increasing. This is because steel production is responsible for a lot of CO2 emissions, mainly due to the use of coal to produce iron, the main component of steel. Currently, about 7% of the Netherlands' CO2 emissions are caused by steel production and processing. By producing iron with sustainably-generated hydrogen in the future, this share can be significantly reduced. Additionally, it is crucial to change the way we dispose of steel products. After all, for all the steel that can be fed back into the production chain, no new iron needs to be made. This circular economy, in which steel is optimally recycled, offers many opportunities in and for the Netherlands.

Tata Steel Nederland is working every day to recycle steel. The company increases the use of scrap from 17% in 2022 to 30% in 2030. This corresponds to 65 billion cans, each containing 13 grams of steel. Tata Steel Nederland aims to further optimize its recycling process. Together with the German steel company Saarstahl and the Austrian voestalpine Group, research has been initiated to explore how digital technology can be utilized to achieve this. Under the name **'Digital Twins for Green Steel' (DiGreeS)**, the three entities are investigating possibilities for introducing new steel production routes and reducing the ecological footprint.

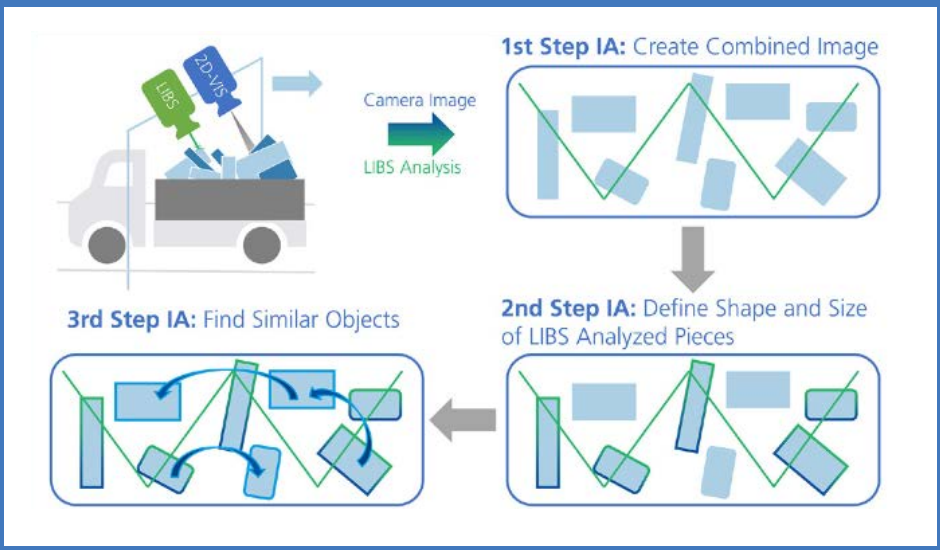
To be able to significantly increase the use of scrap in steel production in the near future, Tata Steel aims to further optimize the recycling process. A challenge in this regard is that much of the old steel, such as from old ships or railroad tracks, is too large in size and quantity for regular conveyors and difficult to analyse. Analysis is important, as not every piece of scrap may be fed into the production cycle. This has many reasons, such as the presence of a coating that complicates recycling, or because the scrap's chemical composition makes it impossible to fulfill requirements on the admissible chemical composition of the recycled steel.

To efficiently analyse large pieces of old steel, Tata Steel researches the use of Laser-Induced Breakdown Spectroscopy (LIBS), a digital laser techniques that enables to analyse the composition of scrap directly from the truck. The process works as follows: a truck carrying scrap enters a specially constructed gate with industrial laser and analysis equipment. The laser vaporizes very small pieces of the steel locally, creating a plasma, a small local gas bubble containing all the components of the scrap. A spectroscope analyses the intensity and wavelength of the plasma light and recognises the composition of the scrap. By combining this information with images of the truck load, individual pieces of scrap can, depending on the specific composition and criteria, be optimally introduced into the recycling process.

AI and digital twins for reduced waste and more CO2 reduction

Tata Steel researcher Bernard Ennis states: "In this measurement and analysis process, AI is used to more quickly recognize and analyse specific types of steel based on visual characteristics, known as 'scrap image recognition'. The manufacturing process is digitally modelled, or simulated, and tested in a computational model using digital twins." This digital twin models the change in the average composition of each type of scrap over time and can thus be used to find the right mix of scrap types that ensures the intended composition of the recycled steel. Moreover, by linking the digital twin to models for mechanical properties, logistics processes or energy management, for example,

Measurement and analysis process for steel recycling.



This innovative combination of laser, AI, and digital modelling allows for more efficient sampling, faster scrap deployment logistics, and improved product quality.

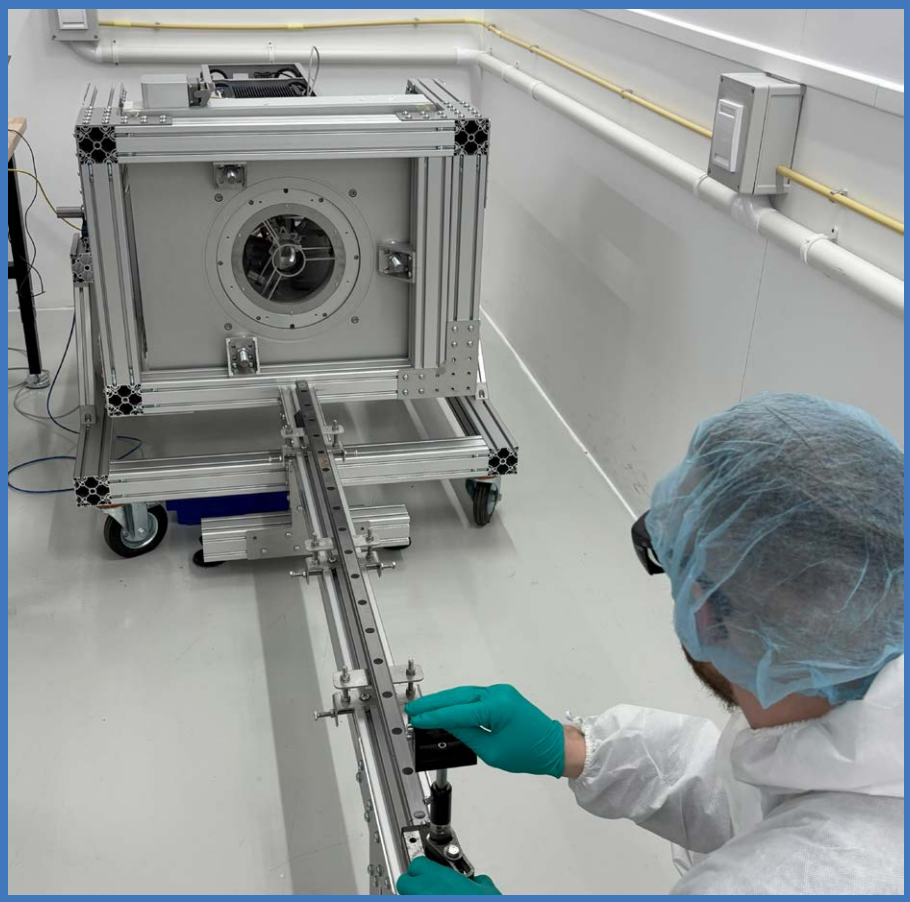
different scenarios can be probed in order to optimise the entire production process. For example, this makes it possible to determine how much scrap can be added before the quality of the recycled steel becomes unacceptable, or to determine an optimal mix of scrap to minimise production losses or energy consumption. “This innovative combination of laser, AI, and digital modelling allows for more efficient sampling, faster scrap deployment logistics, and improved product quality. Moreover, this leads to fewer process errors in scrap deployment and thus less waste and CO2 reduction”, according to Ennis.

At present, the technique is being researched and developed under the ‘DiGreeS program’. The first LIBS measurements are scheduled to take place in the first quarter of 2025, with the first results being announced. In 2026, the first prototype of the truck portal is expected to be ready for use, and the measurements and modelling will commence. Then, the implementation will follow, including the introduction of the digital twins modelled process.

A practical view on the implementation of AI

A successful application of AI stands or falls with a clear view of the intended goal, a clear overview of the strengths and weaknesses of this technology and a well-considered implementation plan.

While promising, AI is not (yet) able to solve all issues within a company, it needs good-quality data to function and it is certainly not yet self-evident to completely outsource important tasks to this technology. How do the researchers at Tata Steel look at these issues?



Laser-Induced Breakdown Spectroscopy (LIBS) testing.

Ennis: ‘At this moment, we already generate a lot of data. Data availability therefore is not the problem for us. The issue lies in the quality and connectedness of the data. The challenge for us is to identify the right data that we can use for a specific purpose and to connect the right data to properly represent a situation.’ In the specific case of the recycling process, there is already a lot of knowledge about how to mix scrap to create the ideal composition, but this knowledge is localised. ‘The trick is to pool this local knowledge and, where necessary for the final result, fill gaps.’ So with this pooled knowledge and already available data, initial AI models can now be created.

Where information is missing, it has to be identified what additional data is needed and how that can be generated, in order to extend the AI models later. This thus makes the practical implementation of AI a gradual process, without a clear on/off switch.

‘Besides, we use AI to make better decisions, not to have it make those decisions for us. If you want to use AI to make decisions, you need to see if AI can do that better than a human for a specific problem.’ This is often the case in situations involving large amounts of data and a lot of repetition. In cases where context, understanding and/or domain expertise is important, humans tend to make better decisions than AI.

Then interaction between humans and AI often leads to better results than humans or AI alone. ‘Steel making can be divided into processes that can be better understood with AI than by a human alone. However, the knowledge and expertise of the whole process cannot (yet) be grasped by AI. In that case, you can use AI to support humans in making better decisions.’ ■

Want to know more about sustainable solutions at Tata Steel? Read more at https://www.tatasteelnederland.com/en/sustainability

> **We use AI to make better decisions, not to have it make those decisions for us.**

PROGNOSTICS & HEALTH MANAGEMENT IN THE ERA OF AI

Introduction

What do airplanes, rockets, wind turbines, coffee machines, nuclear power plants, trains, hard disks, drones, bikes, bridges, ships — and basically any man-made system — have in common? They can, and eventually will, *fail*. If my coffee machine breaks, I shrug and make tea; but when I'm 10 km above the Atlantic, I'd much prefer the airplane to run smoothly. So, the real question is: ***How can we manage our systems effectively by anticipating failure without wasting valuable resources?***

This question has driven generations of engineers and scientists around the world to distil **Prognostics & Health Management (PHM):** a holistic paradigm that helps us monitor our systems' *heartbeat*, predict their performance, and plan courses of action — enabling the management of virtually *any* system.

Now turning our attention to the buzzword of the decade: **Artificial Intelligence (AI).** Far from being mere hype, AI is stepping in to close some of PHM's gaps. In this article, I examine two ideas: *Agents* which act autonomously; and *Large-Language Models (LLMs)* — capable of reading, reasoning and explaining — highlighting their potential to revolutionize PHM by giving our systems a *voice*, helping *us* to help *them*.

Why PHM Matters?

Maintenance engineers are familiar with reactive, scheduled, condition-based, preventive, and other maintenance policies — and attempt to choose the right one based on the problem at hand. Today, however, many industries are betting on two "hot" maintenance approaches: *predictive maintenance*, in which advanced models forecast likely scenarios so we can prepare in

advance; and *prescriptive maintenance*, which generates tailored action plans for precise, effective intervention.

Here, I use PHM as a unifying framework for delivering *health-based decision support* for maintenance, acting as a technical layer of asset management, embedding each system within its environmental, economic, and political context.

Thanks to decades of hardware advances — more powerful computers, expanded storage, and faster networks — we can move, process, and store massive volumes of data, unlocking unprecedented insights. In the past ten years alone, publicly available PHM datasets have more than doubled — a true game-changer that fuels the development of advanced predictive algorithms and flings the door wide open to AI.

The AI Revolution: The Potential of Agents & LLMs on Next-Generation PHM Systems

AI raises debates — philosophical, ethical, technical, and political — provoking constant controversy. I recall lying in bed, reading Max Tegmark's *Life 3.0* and picturing those dystopian and utopian scenarios, thinking, 'Will I ever live to see one of these?' I told myself, 'This won't happen anytime soon — maybe in a few decades.' How wrong I was!

With disruptive technologies like **GPT, DeepSeek, Gemini,** and other "cool kids on the block", we've transformed how we work — opening fresh opportunities in many fields, PHM included. I believe that one of PHM's greatest challenges is the lack of *cohesion mechanisms*: complex systems comprise numerous subsystems, operate under diverse conditions, and rely on expertise from multiple disciplines. Without cohesion, PHM setups can quickly fall apart — so how can AI help? *Let's dive into Agents and LLMs.*

Agent1: 'vibration spike on engine fan blade.' → Agent2: 'reserving hangar slot for blade inspection.'

Articles such as AI-2027 (https://ai-2027.com/) highlight the growing impact of software agents in modern society. These autonomous entities — products of **Agent-Based Modelling (ABM)** — can *perceive, act, and learn.* By embedding sensing, decision-making, and adaptation within each agent, ABM supports emergent, system-level behaviours that arise bottom-up from local interactions.

Conventional heuristics—valued for interpretability — struggle in dynamic, high-dimensional spaces and quickly become outdated. By "dropping" agents into carefully crafted digital worlds, we let them navigate vast mathematical landscapes and adapt policies through experience, refining strategies on the fly. ABM's modular design also supports *context-aware agents* that learn optimal strategies for different scenarios and *multi-agent systems* that collaborate toward shared goals.

Applications of ABM in PHM are booming. Agents can manage other models' hyperparameters (defined before model calibration) as a *control mechanism* — enabling diagnostic and prognostic algorithms to adapt continuously and maintain peak performance — or study component degradation profiles to *learn maintenance policies* that minimize costs while maximizing reliability. These adaptive approaches turn maintenance into a self-optimizing, feedback-driven process.

‘My diagnosis is that you’ve experienced a severe anxiety attack.’ — J.A.R.V.I.S

One of my favourite Marvel characters is J.A.R.V.I.S., Tony Stark’s AI — not just for its sharp humour, but because it embodies the PHM systems I envision. In this scene — System: *“Tony Stark”* → Task: *“Diagnostics”* → Result: *“Identified severe anxiety attack*”— the AI communicates a complex medical insight in plain language. That “voice” bridges system, hardware, software, and end users; you don’t need to be an engineer, scientist, or medic to understand it. The key challenge is that this next generation of PHM systems must mesh advanced, multidisciplinary techniques beneath a seamless *communication layer.*

Advanced LLMs already exist — GPT is one of the most palpable examples — and it’s only a matter of time before PHM systems adopt them. As specialized communication channels, LLMs can translate technical analysis into clear, actionable recommendations between maintenance engineers and technicians. When combined with agents, they enable *co-design mechanisms* — true human-agent collaboration — that power decision-support tools. These tools can propose maintenance strategies tailored to each situation, ensure compliance with regulations and resource constraints, and deliver guidance in language everyone understands, across any domain.

By harnessing agents’ feedback-driven learning loops, we can refine maintenance strategies while revolutionizing data collection. A major bottleneck in PHM is the scarcity of rich, real-world datasets, which hinders model training and validation. Integrating agents with LLMs could enable centralized platforms to gather metrics on maintenance effectiveness, component health indicators, and operational contexts — streamlining messy data processes, generating meaningful datasets, and fuelling continuous improvement and innovation of PHM algorithms.

It’s Not All Rosy: What Could Go Wrong?

Despite AI’s promise, we must balance rapid innovation with robust safety. In PHM, trustworthiness and explainability are crucial: if AI is to guide critical decisions, we need ways to verify and audit its reasoning, and to manage information overload as models evolve faster than can be monitored.

Agents bring their own hurdles: people distrust “black-box” actors, and tuning hyperparameters or ensuring ABM convergence in complex setups remains challenging. To deploy agents reliably in PHM, we need novel algorithms that handle these dynamics while staying transparent and predictable across varied operational conditions.

Traditional LLMs and agent architectures weren’t built for PHM, so we’ll have to adapt them — equipping them with domain knowledge, embedding physics-based constraints,

Despite AI's promise, we must balance rapid innovation with robust safety. In PHM, trustworthiness and explainability are crucial: if AI is to guide critical decisions, we need ways to verify and audit its reasoning...

and tailoring agents to sensor-driven feedback. This demands sustained, focused research into AI-driven PHM technologies.

We also face ethical, legal, and regulatory questions: who is responsible when an AI-driven maintenance decision fails? Addressing accountability and compliance frameworks will be vital as PHM systems gain autonomy. Data privacy and security are also important, as PHM platforms will collect sensitive operational data.

Despite these obstacles, I'm convinced the journey is worth it. Whether we ultimately succeed or hit roadblocks, exploring these technologies promises breakthroughs in system management and sustainability — and personally, I expect plenty of fun along the way!

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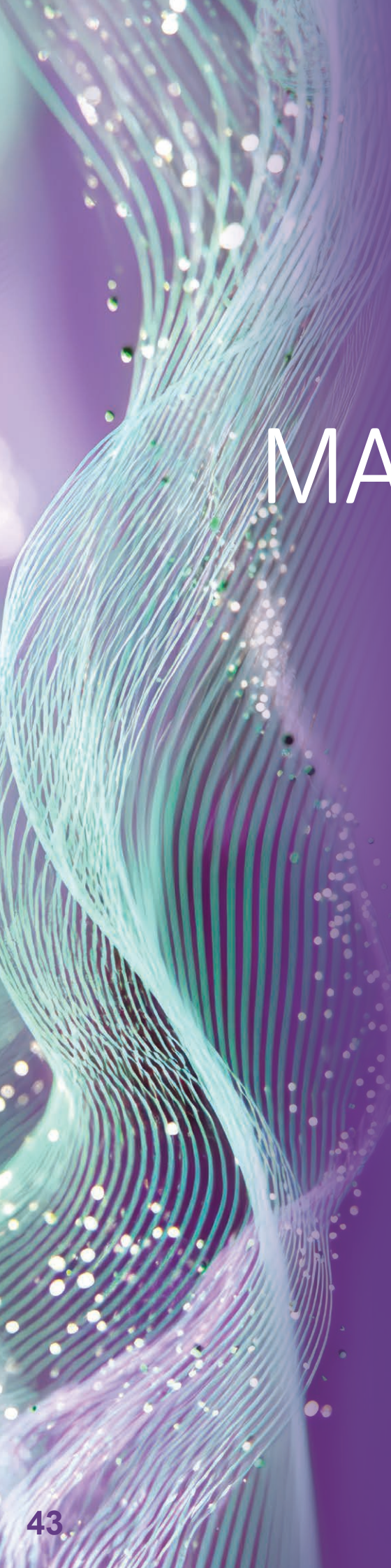


GENERATIVE DESIGN IN MANUFACTURING

HOW CAN YOU BENEFIT?

Generative design is a trend that makes me feel like a kid in front of a new toy: “It looks so cool - I want it!”. Other people’s responses seem to fit two categories. Either you don’t know what it is; in which case, don’t worry about it and continue your life and work as is. Or you have some, or a lot of, an idea of what generative design can do, which can be exciting and worrying. Either way, you are probably curious about what generative design can do for you. This article will give you a quick breakdown of some popular generative design techniques, with emphasis on their applicability in the manufacturing industry.

You have probably heard of the generative abilities of OpenAI’s ChatGPT and maybe used it to request an image of a chicken dancing on a table while wearing a hat (or whatever your creative mind conceived). This is generative design. In slightly more technical terms, generative design is a subfield of design automation that aims to produce a design solution through a defined mathematical process and computer software. While the term “generative design” sounds new, it essentially represents a reframing of existing methodologies for design automation, along with some arguably novel approaches. In this article, I use the term generative design loosely to encompass any form of computer-based design automation. **This may include automations such as parametric design, rule-based design, topology optimization, generative autoencoders, and neural networks.**

As I already mentioned, large language models such as OpenAI’s ChatGPT shifted generative design from amazing to pure magic. The ability to generate virtually anything is what one could describe as artificial general intelligence. However, this comes with hefty performance requirements and an expensive electricity bill. And this is only

the tip of the iceberg, as it overlooks the hours, efforts, and data needed to train such a model. This raises the question: *is this the type of solution that is viable for an SME, and is it sustainable and agile enough to adapt to an SME's requirements?*

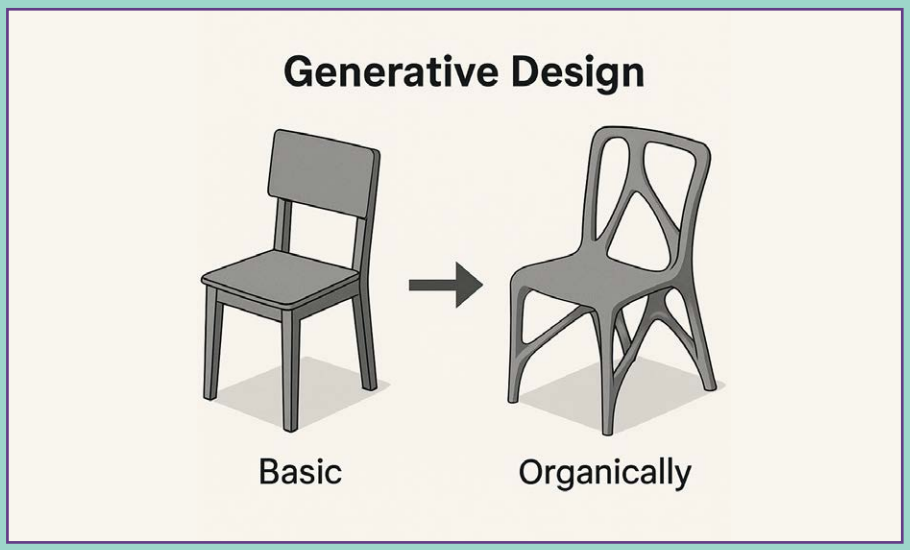
For me, generative design immediately makes me think of variational autoencoders (VAEs) and generative adversarial neural networks (GANs). While the two are not the same, similar requirements come into making them. In simple terms, if we have enough images or other data from a product category, both VAEs and GANs can be used to create a model that can generate new designs fitting the product category. From my experience, when it comes to SMEs, the number of products per category is not high enough to allow for such a solution to be deployed. And while there might be exceptions, it is common for designs within a product category to differ due to regulations, restrictions, or client requirements. Therefore, VAEs and GANs are not very attractive solutions for such products.

The second technology that comes to mind is that of topology optimization. As part of an engineering SME, you may have already seen a demonstration of what topology optimization can do or already be using it. Well, good news, this is considered a generative design approach! Topology optimization can be found as part of most computer-aided-design software nowadays. To generate a new design, you simply define some geometrical constraints, material properties, and a design objective (stress loading, bending, etc.), and the software will use an optimization algorithm to remove or add material until it satisfies the requirements. This works extremely well for single-part designs, but, from personal experience, this is not the solution for more complex mechanisms where the design requirements go beyond some stress and strain performance metrics.

Maybe the issue is that I started talking about technology, rather than a design problem. Identifying the problem can lead to better-fitted automation solutions. The number one issue for an SME, when it comes to design automation, is the **lead time required for new products and the need to stay competitive in an ever-evolving market.** Therefore, the first step to finding where generative design can improve lead times in design development is to identify tasks that are repeatable and time-consuming. From there, one can choose the right technology to address a specific problem. For example, parametric design can be an inexpensive version of topology optimization, where a product already consists of other product blocks. Pattern recognition and data analysis can become a computationally cheaper alternative to a complete design generation, with integration in the existing design process alongside the design engineer. And reinforcement learning can substitute classical design optimization and improve computational times when it comes to recurring but slightly varied designs. And these are only a few examples of how generative design can aid the development process.

If you have reached the end of this article, that means that you are at least a little interested in generative design. So let me end with some words of encouragement. **Design automation is likely feasible at this point for most SMEs.** With constant developments in technologies, computational power, and cloud integration, high-performance solutions become more and more accessible. I would urge you to explore further where generative design is applicable in your case. Either as an end-to-end solution or within a design phase, generative design will improve production time. In the end, automation in the design field is inevitable side-effect of the progressing technology. ■

▼ *OpenAI ChatGPT prompt: generate a figure for generative design using a chair as a product. Keep it conceptual.*



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FROM DOWNTIME TO UPTIME

AI-DRIVEN FAULT DIAGNOSIS WITH GRAPHRAG

Executive Summary

Manufacturers face increasing pressure to reduce downtime and boost operational efficiency, yet diagnosing machine faults remains a slow and error-prone process. A new AI-powered approach, Graph-based Retrieval-Augmented Generation (GraphRAG), is changing that. Developed through project activities in collaboration with the Fraunhofer Innovation Platform at the University of Twente and Dutch manufacturer Mintres BV, this system transforms years of scattered maintenance logs and manuals into structured knowledge that helps engineers troubleshoot more quickly and accurately. By turning unstructured data into intelligent support, GraphRAG enables teams to make smarter decisions, reduce downtime, and retain critical expertise on the factory floor.

Why Maintenance Is Still a Struggle

Despite advances in manufacturing technology, fault diagnosis remains a major bottleneck, largely due to how maintenance data is recorded and stored. Logs are often written in free text, with inconsistent levels of detail, and captured in a variety of formats such as handwritten notes, spreadsheets, PDFs, and emails. These inconsistencies make it difficult to search, analyse, or extract meaningful insights from the data.

Language barriers further complicate matters. Maintenance logs are typically written in local languages for example in Dutch, while equipment manuals and troubleshooting guides are often in English. This makes cross-referencing difficult and error-prone. Key information ends up siloed, buried, or overlooked.

On top of this, the ageing of both machinery and skilled personnel compounds the challenge. As experienced engineers retire or move on, their knowledge frequently leaves with them. Without a structured way to retain and share this expertise, fault diagnosis becomes slower, less reliable, and more expensive.

GraphRAG: Smarter AI for Maintenance

GraphRAG is a next-generation artificial intelligence approach designed to make maintenance work faster, more accurate, and more consistent. It builds

on a method known as Retrieval-Augmented Generation (RAG), which enhances large language models (LLMs) like GPT by enabling them to draw from a company's internal documents and historical records when answering specific technical questions.

While standard RAG systems retrieve relevant documents to support answers, GraphRAG takes things further by converting information into a structured knowledge graph. This graph links fault locations, symptoms, causes, and corrective actions, allowing the system to recognise patterns and offer intelligent, context-aware recommendations. The result is a solution that not only understands language, but also comprehends how your machines operate, where they fail, and how to resolve those failures effectively.

Use Case: Fault Diagnosis in Ion Beam Machine

Mintres BV applied GraphRAG to an Ion Beam Machine (IBM)—a complex piece of equipment involving multiple subsystems such as vacuum pumps, RF generators, and beam controllers. Historical maintenance logs, mostly in Dutch, alongside technical manuals in English, contained a wealth of information that had been difficult to access or utilise effectively.

Using GraphRAG, this unstructured data was extracted and organised into a single, multilingual knowledge graph. Engineers could now interact with the system using a conversational interface, asking questions and receiving answers drawn from years of recorded experience. The AI could connect symptoms to likely causes and proven solutions, regardless of language or document format. What was once a time-consuming search through siloed records became a seamless, knowledge-driven troubleshooting process.

Business Impact: Why This Matters

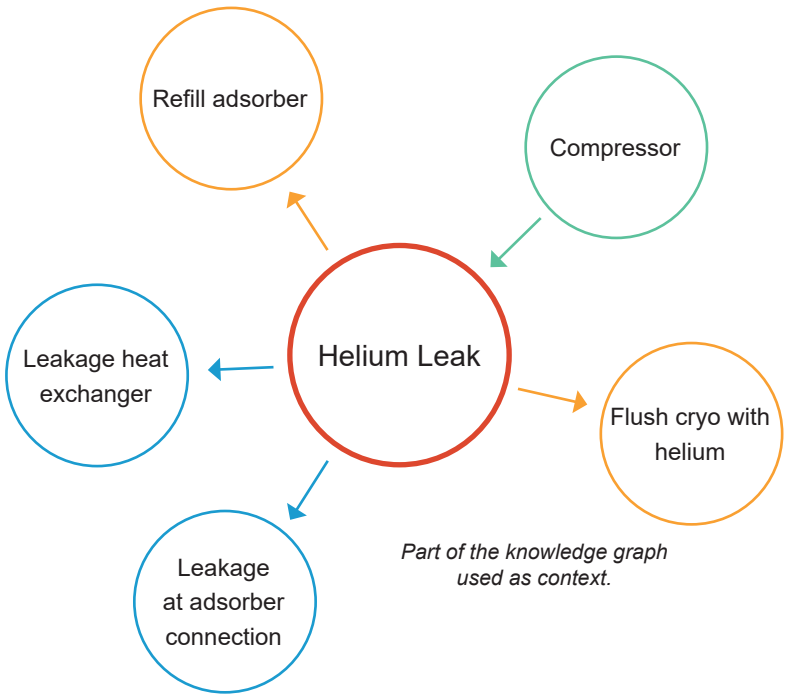
With a clear example of GraphRAG in action, it becomes clear how this technology delivers tangible business value. Converting unstructured, multilingual maintenance data into structured knowledge unlocks a competitive advantage that goes beyond individual fixes. Engineers are better equipped to detect recurring faults and root causes that would otherwise remain hidden. The system captures the insights of experienced technicians and shares them across the organisation, so even newer team members can act with confidence.

The result is more accurate diagnostics, fewer repeat failures, and a smoother maintenance process. This translates into shorter downtimes, lower costs, and greater consistency. Perhaps most importantly, it protects organisations from knowledge loss by ensuring that what senior engineers know is retained, shared, and built upon. GraphRAG doesn't just help you respond more quickly; it also supports the development of long-term resilience.

Conversational Fault Diagnosis with GraphRAG

I found a problem in the compressor: a helium leak in the heat exchanger. What is the cause and the solution?

The helium leak in the heat exchanger may be due to leakage at the exchanger or adsorber connection. Recommended actions include replacing the heat exchanger and adsorber, flushing the cryo system and hoses with helium, and refilling the adsorber with activated carbon.



Part of the knowledge graph used as context.

> **With a clear example of GraphRAG in action, it becomes clear how this technology delivers tangible business value. Converting unstructured, multilingual maintenance data into structured knowledge unlocks a competitive advantage that goes beyond individual fixes.**

How to Get Started

You do not need to start from scratch to take advantage of GraphRAG. Begin with what you already have, such as maintenance logs, service reports, manuals, and shift records. Choose a single machine or system as a pilot to prove the concept. This focused approach helps manage scope and build confidence before scaling further.

Engage domain experts early. Their experience is essential in validating data accuracy and ensuring the output is both useful and trustworthy. Collaboration between engineering, data, and IT teams is vital to success. Together, they can align goals and develop an effective integration strategy.

By taking an incremental approach, your organisation can reduce risk and begin seeing benefits quickly. Each additional system or machine strengthens the knowledge base and increases the system's overall value.

Augmenting, Not Replacing

GraphRAG is not about replacing skilled workers; it is designed to augment their abilities. The system takes on the time-consuming task of digging through logs and manuals, freeing engineers to concentrate on problem-solving and continuous improvement. Their insights become part of a shared knowledge system, allowing the entire team to benefit from their experience.

As team composition changes over time, the knowledge remains. New engineers can ramp up faster, and maintenance practices become more consistent. In this way, GraphRAG strengthens both individual performance and organisational memory.

AI solutions like GraphRAG are transforming maintenance by making it faster, smarter, and more resilient. Instead of reacting to problems as they arise, manufacturers can anticipate them, diagnose them accurately, and resolve them efficiently. By turning fragmented data into usable knowledge, organisations protect themselves from disruption, reduce operational risk, and unlock real value from their existing information.

The future of maintenance is already within reach. It starts with your data and the decision to put it to work. ■

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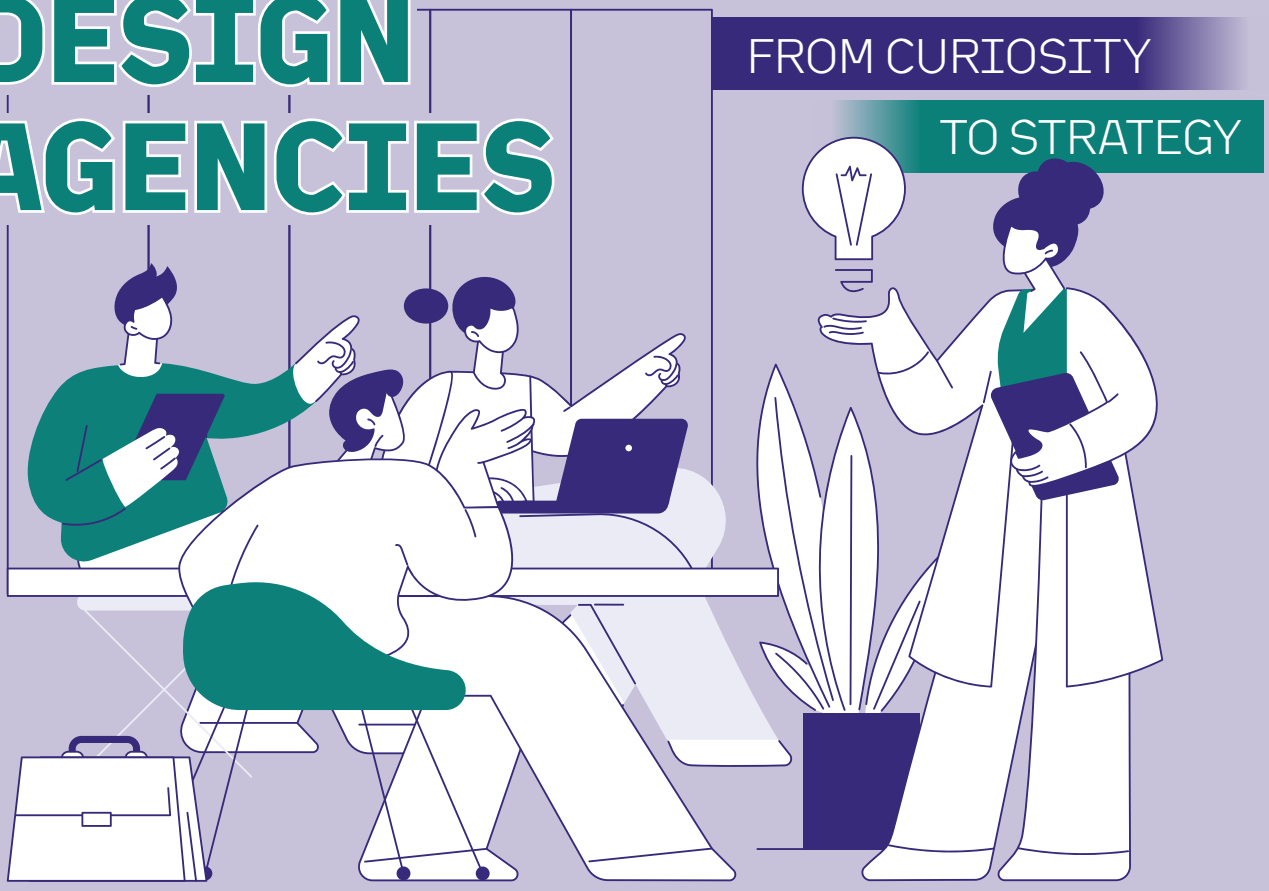
AI AT DESIGN AGENCIES

FROM CURIOSITY TO STRATEGY



Since the launch of ChatGPT in 2022, generative AI has been evolving rapidly. In many sectors, this technology gained attention, and design agencies are no exception. Design agencies are intrigued by the potential of AI, but at the same time struggle with the questions: How can AI be integrated into the design process? When does it add value? And if we don't act now, are we at risk of falling behind?

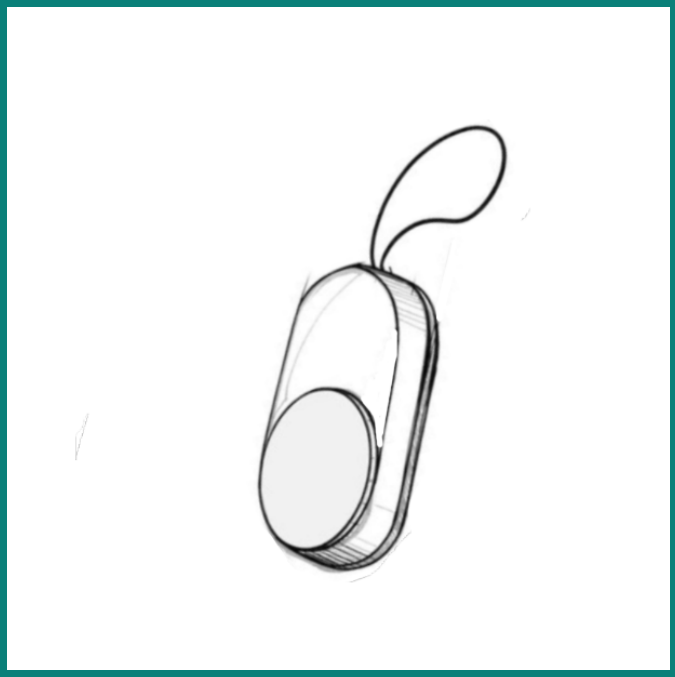
AI in Design: A Project in Practice

With these questions as a starting point, the Industrial Design research group at Saxion University of Applied Sciences launched the *AI in Design* project in October 2024. Together with design agencies 100%FAT, DE Design and Dynteq and an AI expert from VIRO, the project explores how generative AI can contribute to the design process. This exploration takes place along two lines: the capabilities of the tools, and the perspectives of the designers.

The project aims to better understand how generative AI can support complex design challenges. This requires understanding of the capabilities of the technology, the needs of designers and the culture within their organisations.

Interviews were conducted with designers and AI experts to explore how AI fits within the identity of design agencies and where the designers' needs lie. These interviews also helped to gain insight about relevant AI tools. A large group of students then tested AI tools across various stages of the design process.

Promising tools were distributed to partners, each supported by custom guidance tailored to the company's needs. Within the research group, we monitor this implementation process and, together with the partners, reflect on the tool and its implementation. Focus groups further provide valuable insights into the cultural and organisational aspects of AI adoption.



Handmade sketch of a keychain.

Render of sketch after expanded prompt in Vizcom.

From ChatGPT to Vizcom: How Designers Are Using AI

Several generative AI tools were tested during the project, leading to a variety of applications and strategies.

ChatGPT and other language models are used as starting point for market research, trend analysis and patent research. Designers also uploaded product requirement documents (PRDs) into these tools to receive a second opinion based on their own past PRDs. In these cases, the tools serve as a check on human findings to ensure high quality. Furthermore, these tools support prototyping by generating code and creating mock-ups.

Vizcom allows designers to convert handmade sketches into 3D renders. This tool is fast, allows for a lot of variation, and helps set a certain mood or style. It makes communicating ideas a lot faster and more accessible.

Midjourney, Dall-E and other image generators support designers with inspiration and communication of ideas. Rather than searching online for hours, designers can generate images that align closely with what they've imagined. These tools are still hard to control, so designers mainly use it for impressions rather than concepts. The tools are also used to enhance presentations by generating high-quality visuals.

But the tools are not perfect. Especially in detailing phases of the design process, designers run into limitations. The output can be inconsistent, difficult to control or simply not useful. As a result, confidence in AI declines and designers are more likely to give up experimenting with AI-tools.

Since AI tools cannot do everything, their strength lies mainly in combining the tools with traditional design tools and human expertise. For example, designers can use Vizcom to generate a lot of product variations, then use a graphics editor or CAD software to refine the outcome.

Similarly, a render of a product might benefit from a compelling setting. Instead of modelling that scene manually in Blender, designers can now use tools like Midjourney or DALL·E to create a fitting background, into which the product is placed. This hybrid approach saves time while maintaining visual quality.

Company culture as key to AI adoption

Interviews show that organizational culture plays an important role in AI adoption. Designers vary widely in their attitudes towards AI: some experiment enthusiastically, while others are cautious due to ethical concerns such as energy consumption. In many companies, AI is barely talked about, which hinders its use and slows down the development of AI literacy. This also prevents important discussions about how AI fits the identity and values of the company. These conversations are essentials, specially where you desperately need people with different attitudes.

Besides technical aspects about the tools, there are also fundamental questions among designers. Many designers wonder: ***Will this remain as my design if I use AI? What does this mean for my creativity? Where does my added value lie?*** Because agreements are rarely made within

3D feature from Vizcom to add different perspective.

companies, AI use often remains under the radar and people get the idea that using AI is cheating.

The advice? Have conversations within the company about AI. Make explicit what your identity is as a company, and under which conditions you do or do not want to use AI. This creates ownership, direction and clarity within the company, but also towards customers and partners. It also prevents frustration and embarrassment between colleagues with different views, which can hinder cooperation and efficiency of AI use.

Working with AI step by step

AI tools offer many possibilities, and with lightning-fast technological developments, those possibilities will only increase in the coming time. Low AI literacy often creates unrealistic expectations and additional frustrations. The reality is that applying AI requires time, curiosity and collaboration to exploit those opportunities. In many cases, it does not yet speed up the process, but it can improve quality in the areas designers currently pay little attention to. What helps with this is starting small: pick one application, test it, and discuss with your team what it achieved. The best way to build confidence in AI is by doing, reflecting and thus learning together. ■

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The advice? Have conversations within the company about AI. Make explicit what your identity is as a company, and under which conditions you do or do not want to use AI.

AI FOR PROCESS OPTIMIZATION

IN A MANUFACTURING COMPANY

Novel T

In 2025, we can no longer ignore AI. However, it is not always easy to integrate such a new technology into your company. Family business Pentas Moulding did not shy away from this challenge. With the help of European Digital Innovation Hubs (EDIH), the company realized process optimization that completely changed their way of working. Marthijn Koorn, Commercial Director at Pentas Moulding, explains how this manufacturing company remains at the forefront.

Pentas Moulding was founded in 1975 in Almelo and produces plastic products for the manufacturing industry, always tailor-made to the customer's wishes. They have a clear vision in mind: focus on automation to be technically progressive. "We have always been involved in innovation in the field of IT and technology," says Marthijn. "We started developing our own ERP system in 2000 and our factory is paperless. In recent years, we have linked all machines and sensors to our databases, so that we have an even better grip on the quality we deliver. So we are always looking at how we can use new technologies to make our work more efficient. Now with AI, a new era is dawning, which offers a lot of opportunities."

Personal AI-Assistant

Two years ago, they started using ChatGPT to write emails, and translate texts, but also to digitize manuals. But the use of AI goes further than that. Marthijn: "We have made ChatGPT available on our machines. In the event of a malfunction, a technical employee

> **We want to be an example for other companies in the transition to a more sustainable and data-driven future.**
>
> *- Marthijn Koorn, Commercial Director Pentas Moulding*

can ask what to do, or ask how the machine has performed compared to other machines. But also what needs to be done for even better performance." Another application they have found is in the vision system. Cameras perform video analyses on how a product is post-processed, for example. This way, AI can quickly interpret what the employee is doing and help them when they deviate from the procedure. "Every employee will soon have a personal AI assistant," says Marthijn. "This will not only make us more efficient and flexible, but also more attractive as an employer in an increasingly competitive market."

More than Process Optimisation

To find the right direction, they called in the help of Novel-T. "They helped us get in touch with the right people, such as partners and experts who guided us through the AI integration," says Marthijn. "We also received help with financing options, such as EDIH. Thanks to this support, we have now been able to lay a solid foundation for future innovations." This is not yet the end of Pentas Moulding's digitalization. Marthijn: "The impact of this digitalization goes beyond just process optimization. It fundamentally changes the way we work. We are now working towards a more connected organization in which technology and people work hand in hand to achieve better results."

Example for Others

Of course, we do not know what other technologies will emerge in the future. But one thing is certain: Pentas Moulding will continue to invest in innovation. "Not only for ourselves but also to contribute to the development of the industry as a whole," says Marthijn. "We see a future in which AI is an integral part of all our processes, with a personal digital assistant for all colleagues. Our factory will only become smarter, more flexible, and more sustainable, with minimal waste and maximum efficiency. In fact, we want to achieve more with fewer resources and produce completely CO2-neutral. We want to be an example for other companies in the transition to a more sustainable and data-driven future." ▪

PENTAS

Pentas Moulding in Almelo is one of the most modern and advanced companies in Europe when it comes to producing plastic rotational moulding products. Since their inception in 1975, they have viewed technology as the basis for optimal delivery of client-specific plastic products.