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SMEs guide to transforming manufacturing with AI

How to implement step by step AI in manufacturing SMEs

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Content

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This white paper is made for small and medium-sized manufacturers interested in implementing Artificial Intelligence in their operations. Whether your organization is at the initial stages of considering AI implementation or seeking guidance to optimize existing initiatives, this guide provides a practical framework and recommendations tailored specifically to manufacturing SMEs.

Preface

Mastering AI through collaboration

The operation of production machines (robots, processing centers), whether old or new, requires ensuring maximum utilization of these assets. This is achieved through increasingly precise control of downtimes to ensure the maintenance of the machinery.

When addressing the topic of maintenance, the terms predictive maintenance and artificial intelligence analysis very quickly come to mind. This “black box AI” is obviously complex to implement for an industrial company that does not have the internal resources and skills to master advanced statistical tools.

The “AI for SMEs” project initiated by the initiative Industrial Transformation of Basel Area Business & Innovation has made it possible to open this black box to demystify the use of this analytical tool, AI. One of the main lessons Liebherr France has learned from participating in this project is that even a simple subject area, namely the monitoring of a single function of the machine, enables a very thorough learning of the necessary technologies. Through this project, our teams have increased their skills in terms of machine connectivity (IIoT), the collection of machine data during operation and the analysis of this data in conjunction with the logged operations.

However, this AI challenge could only be tackled through the collaboration of several partners brought together by Basel Area Business & Innovation. The pooling of expertise within this project made it possible to efficiently address the use case proposed by the industry. This type of collaboration is necessary to learn how to master a technological building block as complex as AI.

The management of the “AI for SMEs” project by the Industrial Transformation team of Basel Area Business & Innovation has been able to establish a very positive team spirit in a tri-national working environment. We congratulate this team for the rich learning and experience gained during the project.

Stephan Kohler
Adjoint au Directeur général Production
Liebherr France SAS

1. Artificial Intelligence as a catalyst for innovation

Unfortunately, there is no magic button for instant innovation. However, through our longtime experience with small and medium enterprises (SMEs) from the trinational region of Baden-Württemberg (Germany), Basel Area (Switzerland) and Grand Est (France), and our dedicated innovation programs, we gained useful insights that we want to share with you.

This white paper focuses on the implementation of Artificial Intelligence (AI) in manufacturing SMEs featuring real examples from companies in the trinational region. It aims at providing a pragmatic framework to overcome typical challenges when engaging with AI for the first time and hopefully eases the path for entrepreneurs who want to make the most of it.

1.1. The innovation imperative

Small and medium companies need to innovate to stay competitive in today's rapidly changing business environment. One major factor driving the need for innovation is the continuous change in demand. Customers increasingly expect products and services to be delivered faster, with greater convenience and at lower costs. Companies that fail to meet these demands risk losing market share to their competitors.

Cost pressure is a further key driver of innovation. With rising production, energy, and materials costs, manufacturers need to find ways to reduce expenses and improve efficiency to remain profitable. Innovation helps SMEs achieve these goals by developing new products and services, optimizing production processes, and improving supply chain management.

The rise of digital technologies and automation is also disrupting traditional business models and creating new growth opportunities. Businesses that fail to adopt these transformative technologies risk being left behind by more innovative competitors.

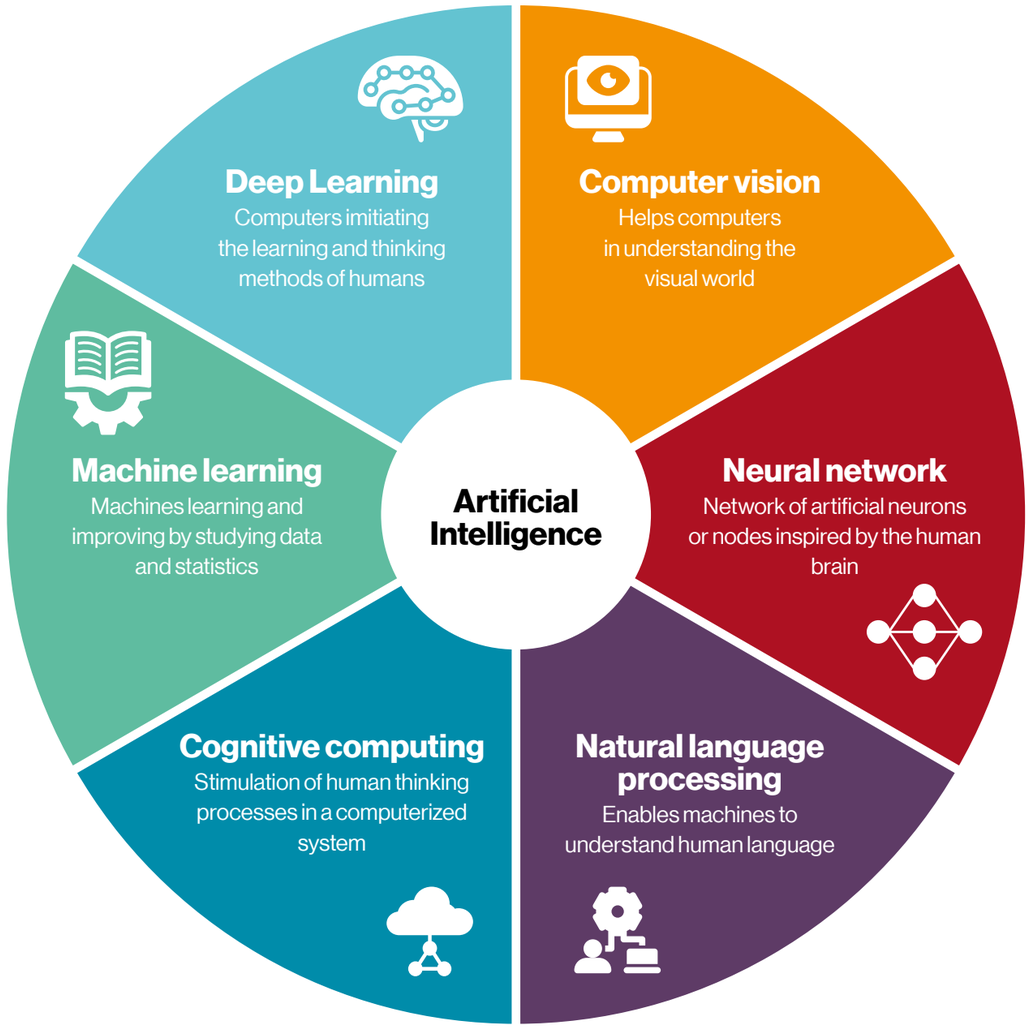
Finally, the availability of the workforce is changing with the increasing adoption of Artificial Intelligence (AI) and digital technologies. As businesses automate more tasks, the skills and knowledge required of the workforce are shifting. SMEs that fail to adapt to these changes risk being unable to attract and retain the talent they need to remain competitive.

In summary, SMEs need to innovate to meet changing demands, reduce costs, adopt emerging technologies, and adapt to changes in the workforce. Failure to do so risks losing market share, falling behind competitors, and becoming less relevant.

1.2. The substantial benefits of AI in Manufacturing

You might be tempted to think the next big thing will follow AI anyway. So why jump on it now? You are right, "the next thing" will forever be around the corner. And yet we are certain this transformative technology will not go away anytime soon, mainly because the potential benefits are huge.

Key components of Artificial Intelligence



Artificial Intelligence or "AI" is a branch of computer science that focuses on creating systems capable of performing tasks that usually require human intelligence. These tasks include problem-solving, understanding natural language, recognizing patterns, and making decisions.

1.2.1. Enabling operational efficiency and cost savings

Leveraging Artificial Intelligence, particularly in robotics and automation, allows manufacturers to refine their production workflows. AI-driven robotic systems, for example, excel in repetitive assembly tasks, ensuring precision and speed, resulting in enhanced operational efficiency and cost savings.

Predictive maintenance, enabled by AI algorithms, can help optimize maintenance schedules and avoid unexpected equipment failures. By monitoring equipment performance and identifying signs of potential issues, manufacturers can reduce downtime, extend the lifespan of machinery, and improve overall operational efficiency.

1.2.2. Guaranteeing product quality

AI algorithms can analyze sensor data in real-time to detect anomalies or deviations in the production line (computer vision). This proactive approach enables SMEs to identify and resolve quality issues promptly, ensuring that only high-quality products reach the market.

1.2.3. Opening new business opportunities

The leverage achieved through the activities mentioned above allows SMEs to take on more substantial manufacturing contracts with confidence or even explore new markets. For example, products can further benefit through supplementary services like AI-assisted setup or remote technical support. Additionally, new insights can be synthesized from complex data. This also presents a chance for differentiation in existing and new markets.

In summary, AI presents significant advantages for manufacturing SMEs and innovation of the sector as a whole.

1.3. Blockers to AI adoption in SMEs

While the AI boost is real, so is the reluctance to engage with it. During our AI4SME program, we identified four categories of blockers that keep small and medium enterprises from implementing Artificial Intelligence in their business:

— **Skepticism about AI:** The greatest concerns relate to legal uncertainty. In a Bitkom Study from 2022, the main mentions were the "fear of violations of data protection guidelines" and questions about "liability obligations" in the event of damage. Another risk is seen in the "lack of transparency about how an AI works". The AI is seen as a "black box" whose results are difficult or impossible to understand and consequently, incorrect behavior - whether due to inadequate data, programming or application errors - is difficult to recognize. Concerns about acceptance due to ethical aspects are increasing and will gain even more attention in the future (Swiss AI Report 2022, MEDEF 2019, Zhang et al. 2022).

— **Missing resources:** Companies indicate three types of missing resources: firstly, human resources, secondly, a data, and thirdly, funds (Bitkom Research 2022, Swiss AI Report 2022). In particular, there is a lack of data scientists and machine learning engineers. Concerning data, it is often not the shortage, but data incompleteness and heterogeneity that becomes the biggest hurdle.

The quest for talent apt in AI is recognized by the national and EU wide strategies (AI Strategy Germany 2020, AI Strategy Switzerland 2023, AI Strategy France 2021 and AI Strategy EU 2021): Significant investments are allocated to the training of AI experts with the goal of attracting international experts for teaching and encouraging more people to study in the AI field. The cost of AI model training, however, has more than halved in the last 5 years, so the financial gap will continue to shrink in the future (Zhang et al. 2022).

— **Lack of urgency to transform:** Less than half of the companies in Germany, Switzerland and France are active in the field of AI (EFI 2022, Bitkom Research 2022, Swiss AI Report 2022). Unfortunately, the study did not ask whether the companies had invested in other digital technologies, such as IoT. Consequently, we cannot derive any general statements about the openness towards digital technologies. But this tendency underpins the concern that middle European countries fall behind in digital key technologies, leaving the economic playground of AI-based products and service sectors to other nations.

— **Not knowing where to start:** According to our experience with the AI4SME projects, many companies have difficulties finding their way into the AI world, partly because these projects are perceived as complex, but also because they have no clue on how Artificial Intelligence can concretely help them in their business activities. They require a vision and a broad field of competence in the project team: The team needs to set up the digital infrastructure for data management, maintain data pipelines and implement AI to the application layer.

1.4. How our region supports SMEs in adopting AI

To address these challenges, the trinational region has been highly active in promoting Artificial Intelligence adoption among manufacturing SMEs.

For example, in Baden-Württemberg, Germany, the government has launched several initiatives to support manufacturers in adopting AI technologies. The "Digital Hub Applied AI Karlsruhe" in Baden-Württemberg, for example, offers a networking platform and a large partner network to encourage AI use.

In Switzerland, the government has launched the "Digital Switzerland" strategy, which includes activities to promote the development and use of AI technologies. And Basel Area Business & Innovation supports companies in finding the right partners to launch AI projects.

Similarly, in France, the regional government of Grand Est started initiatives to support the development of AI expertise and the adoption of its technologies among small and medium-sized businesses. For example, there are special clusters and networks, such as the "AI Valley" in Grand Est, which provide expertise and resources for SMEs.

Overall, while there are still challenges ahead, the regions of Baden-Württemberg, the Basel Area and Grand Est are promoting the adoption of AI and have available resources to support small and medium enterprises in this area.

AI4SME paves the way

With the Artificial Intelligence for SMEs (AI4SME) program, we are ensuring that entrepreneurs become aware of the vast opportunities of Artificial Intelligence, exchange experiences, identify internal projects and establish cooperation. In this way, we help to render the risk of change more manageable for them and get them excited about digital transformation.

We also foster cooperation between SMEs and startups, universities of applied sciences, universities, competence centers and other institutions in the trinational region.

Furthermore, we offer financial support in cooperation with the national research programs and provide expert support during a proof-of-concept to enable SMEs to master their first AI steps successfully and in a safe and encouraging setting.

→ Find out more
www.innovate.baselarea.swiss/de/blog-post/ai-for-sme/

2. Use Cases from the AI4SME program

Despite the availability of support, small and medium-sized manufacturers might have difficulties starting their AI innovation journey. This is why, three years ago, Basel Area started working on a standardized process that would allow SMEs to quickly develop AI solutions and implement them in their manufacturing processes.

From the start, it was clear that collaboration was the key to innovation. The program brought together our industry partners, active experts and community members and secured governmental support (NRP) to exchange ideas, share experiences and encourage one another.

With our combined knowledge, we have helped eight companies — four of which you will meet below — to design and develop a proof of concept (POC) for an AI project that can meaningfully transform their businesses.

“In the field of electric motors, innovation is not just about replacement, but about upgrading for a sustainable future.”

Michael Kummer
CEO Küffer Elektro-Technik (KETAG)

2.1. Küffer Elektro-Technik AG (KETAG)

Finding the most suitable and energy efficient replacement electric motor

Küffer Elektro-Technik AG (KETAG), headquartered in Kirchberg (Switzerland) and with a branch office in Basel specializes in drive and control technology. Established in 1949, KETAG offers independent testing and repair of drive systems. With an extensive inventory of motors and electrical components, they provide timely solutions during equipment outages.

The challenge: improving the energy efficiency of the industrial landscape
Electric motors play a pivotal role in Switzerland’s industry, consuming about 50% of the nation’s electricity. However, when these motors malfunction, leading to unplanned plant outages, the immediate response is often to replace them with identical models. This approach overlooks the potential to upgrade to more energy-efficient alternatives.

The solution: bridging expertise gaps with an AI-driven platform
KETAG believes in the industry’s drive towards energy efficiency. To facilitate this transition, they introduced an AI-based platform, the TSapp. This platform leverages Optical Character Recognition to extract data from photos of motor type plates. An intelligent matching algorithm then compares this data with the IEC standard, automating the search for an appropriate new motor. This seamless process culminates in a list of recommended electric motors, aiding in the swift procurement of replacements.

The result: boosting industry sustainability and reducing energy consumption
KETAG’s AI solution stands out for its manufacturer-independent approach, capable of reading type plates spanning various ages, even those 40 years old. This tool bridges the expertise gap in the industry, especially given the current shortage of skilled workers. By simplifying the process of identifying energy-efficient motor replacements, KETAG empowers customers to achieve sustainability goals and reduce electrical energy consumption.

Sensors on electric motors

2.2. Willemin-Macodel SA

Evaluating component deterioration on a machine tool

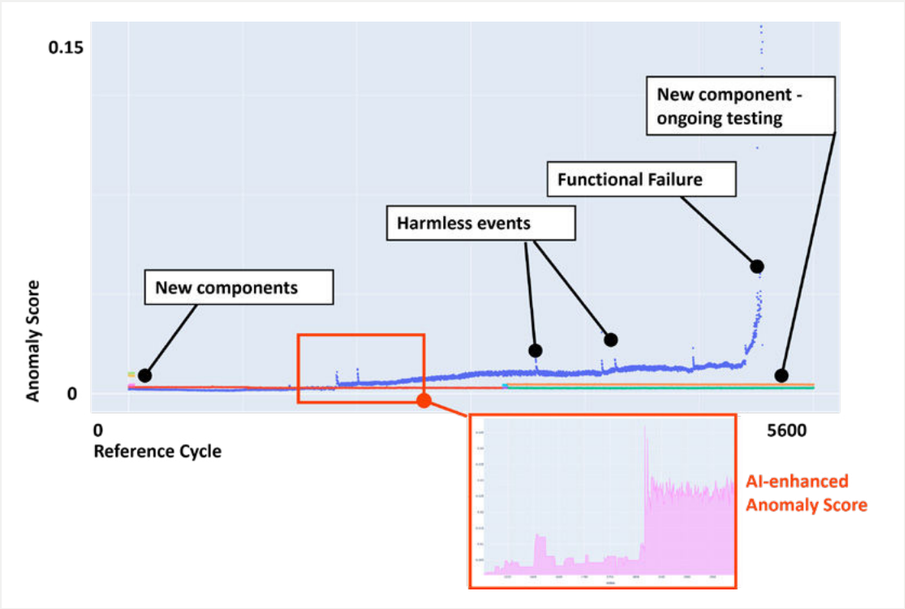
Willemin-Macodel SA, based in Delémont (Switzerland), is a leading provider of advanced machining solutions. Established for decades, they specialize in high-precision machining tools for industries such as micromechanics, medical/orthopedics, the watch industry, and jewelry, among others. Their innovative approach has made them a go-to name for tailored machining needs.

The challenge: predicting component deterioration

In the manufacturing world, the degradation of workpiece quality often signals the need for the replacement of a mechanical component. This degradation leads to production halts, causing significant downtime from the moment an issue is detected to the intervention of after-sales services. The ability to predict component deterioration days or even weeks in advance could streamline replacements, minimizing production disruptions.

The solution: an AI-based test cycle to gauge component health

Willemin-Macodel embarked on a mission to devise a test cycle that gauges the health of a specific component using signals from the machine controller. The proof of concept (POC) aimed to discern the suitability of available signals and their sampling frequencies for this purpose, pinpointing the most relevant ones. The goal was also to determine which test conditions are the most suitable to highlight components defects effectively, based on parameters like speed, position or force.



Analysis of collected data

Machines of this caliber come with a plethora of parameters, that might depend on customer-specific settings or on the machine's condition. Ensuring consistent states across machines during the component health analysis is challenging. Every parameter change can lead to measurement discrepancies that are hard to rationalize. In this context, distinguishing between critical and harmless defects is essential for success. Automating setting adjustments and learning from several systems will yield comparable measurements and robust analysis. Here, CSEM and Alpamayo's expertise and set of toolboxes lead to very promising results.

The result: a solution born out of collaboration with AI experts

Close collaboration with carefully selected partners allows one to have access to expert skills on rather short notice. This process was very much facilitated with the support of the Industrial Transformation team of Basel Area Business & Innovation. Initial partnerships were forged with CSEM, and later for AI programming with Alpamayo.

"In the intricate dance of machinery, predicting a misstep can be the difference between seamless production and costly downtime."

Vincent Chenal
R&D Engineer EPF (Willemin-Macodel SA)

2.3. Raurica Wald AG

AI-based timber volume calculation with «DeepForest»

Raurica Wald AG, headquartered in Muttenz (Switzerland) and with a production site in Breuleux, is a leading force in the regional forestry and timber sector. Representing forest owners and sustainability-driven investors, the company champions the sustainable use of regional forests. Their operations ensure consistent wood turnover and value maximization for both forest owners and investors.

The challenge: improving timber volume estimation

Estimating the volume of felled or standing timber has traditionally been a manual and time-consuming task. While the existing app, MobiPolter, facilitated digital recording of timber, the actual volume estimation remained a human challenge. The spark for innovation was ignited during a casual brainstorming session over coffee.

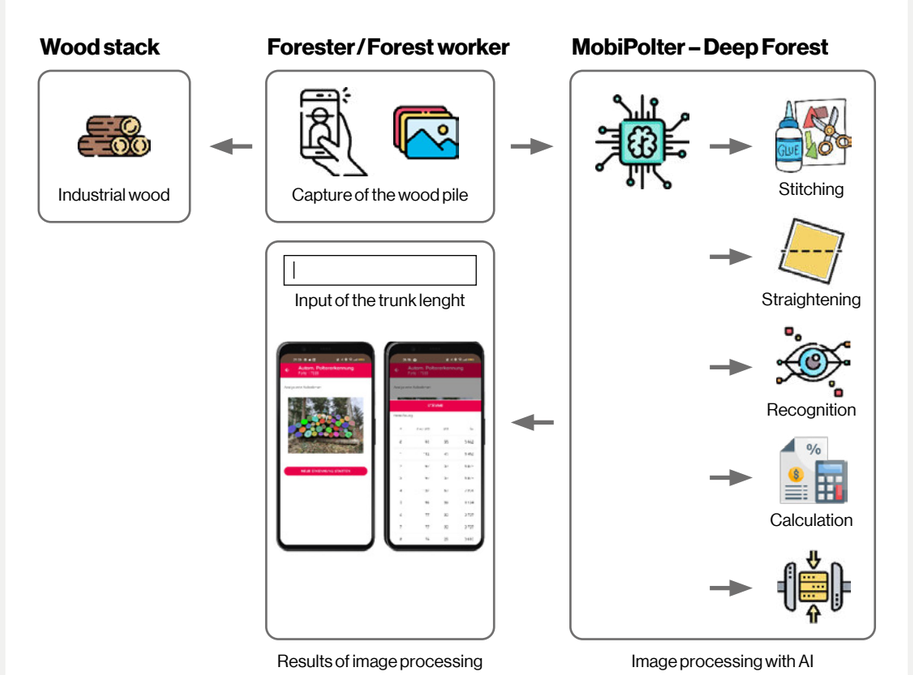
The solution: an AI-based timber volume calculation tool

The forester pulls out his smartphone in the middle of the forest and takes several photos of the pile of timbers. These are processed in the DeepForest-Cloud, after pre-processing an algorithm transforms the images into a 3D mesh and a special artificial intelligence calculates the volume - all in a fraction of a second. As a result, the forester receives the evaluation, an analysis with images and has the opportunity to intervene if he does not agree with the AI results. The next steps will focus on training and testing the model in real forest environments.

The result: interdisciplinary collaboration as key success factor for DeepForest

The journey underscored the importance of interdisciplinary collaboration, where experts from different disciplines came together to develop useful solutions collaboratively, creating innovation and collective benefit. This approach created added value that propelled SMEs forward in the market. The streamlined process, time savings, and enhanced accuracy of calculations greatly benefited foresters and forest workers, as well as downstream customers like sawmills and transporters. Securing financing for full-scale implementation post a successful proof-of-concept was a challenge, emphasizing the need to define a sustainable business model aligned with the solution's value proposition. As the project progressed, new requirements and enhancements emerged, highlighting the importance of capturing these ideas for future integration while staying focused on the primary project objectives.

Wood piles identified with AI



Deep Forrest solution concept

2.4. Liebherr France

Predictive technologies and solution for machine dysfunctions detection

As part of the multinational equipment manufacturer Liebherr, Liebherr France (based in Colmar, France) is specialized in Crawler excavators and special machinery for demolition and earthmoving, steel industry and industrial handling, as well as civil engineering and tunneling.

The challenge: proactive machine failure prevention

Machine failures can lead to significant downtime, affecting productivity and incurring substantial costs. Liebherr recognized the need to proactively anticipate these failures and streamline repair times. However, a lack of comprehensive data on machine failures and their criticality posed a challenge. Moreover, in about five percent of unplanned breakdowns spare parts were missing, further delaying the repair process.

The solution: AI-driven early detection and streamlined repair

Liebherr embarked on an ambitious journey to leverage AI for early detection of machine dysfunctions. By collaborating with partners like Basel Area Business & Innovation and Predict, they developed a proof-of-concept aimed at collecting and analyzing machine data more effectively for their PAMA 3 machine. All variables are now accessible on the machine's Siemens PLC (programmable logic controller) and are recorded and viewable. Below is an example of a Dashboard (named "Production") allowing to follow the progress of the programs, tools, and axes positioning.

The result: reduced downtime and enhanced repair efficiency

Liebherr faced a significant challenge with machine failures causing downtime and delays due to missing spare parts. To address this, they embarked on an AI-driven solution that aimed to detect machine dysfunctions early. By collaborating with partners and developing a proof-of-concept, they were able to collect and analyze machine data more effectively. This resulted in a dashboard that allowed them to monitor the progress of programs, tools, and axes positioning. The outcome was a significant reduction in machine shutdowns, with one intervention lasting only 10 minutes. Liebherr can now analyze machine malfunctions and find solutions more quickly, ultimately improving productivity and reducing costs.

3. Framework: How to start your AI journey

SMEs can start an Artificial intelligence project by following a systematic approach that matches their needs and capabilities. This includes selecting the right pilot project and AI engineering methodology while considering organizational, business, and technical criteria. During planning and implementation, risks need to be mitigated and learnings captured to help the organization towards an integrated approach to Artificial Intelligence including building up the necessary skills. These steps are illustrated in detail in this chapter.

3.1. Choosing and organizing a pilot project

Many companies struggle to prioritize investments that do not offer immediate returns. So, the choice of the use case is fundamental. It must be simple, clear and provide benefits regarding efficiency, productivity, or forecasting as described in chapter 1. Further aspects to consider are:

— **Data availability and technical feasibility:** Keep in mind that it is the easiest way to get into AI projects in an area where data is already available – apart from manufacturing – this is usually the case in the commercial and marketing business processes. Here, Artificial Intelligence can significantly shorten document handling times through (semi-)automated text processing or help to analyze customer and market data to build customer-specific marketing strategies. When picking the pilot project, it is prudent to ensure a connection between the project objectives and the core organization's strategy.

Moreover, SMEs should ensure they have the necessary IT infrastructure for the project's optimal technical performance and eventual success. This includes considering technical processes and decisions that significantly influence the success of the project, such as data collection and handling, application modeling, and deployment throughout the project's entire life cycle.

— **Project scope and Return-on-Investment:** SMEs should define the project aim and scope and cater to the target user's needs, whether they are customers or employees. Project managers should also consider the process duration and costs associated with the project as well as carefully define in and out of scope deliverables.

Unfortunately, many companies fall into the trap of investing excessive energy in avoiding potential errors. Although calculating the Return on Investment (ROI) for individual Industrial Internet of Things (IIoT) use cases can be challenging, especially at the beginning of the cloud-based production journey, a proactive mindset is essential for long-term success.

If the POC works, the results must translate into a positive return on investment that is specific to your business and shows enough value potential to convince other stakeholders to invest in Artificial Intelligence on a larger scale.

— **Internal and external resources:** More than any other project, an AI project must be planned with care. An adequate project documentation and project organization are especially essential. Additionally, the project manager should be able to act as a bridge builder between the business and the AI engineers and have the full support of the board and CEO.

Developing and implementing an AI use case requires an understanding of the manufacturing process and of AI methods. Often, a single expert, department or even company will lack knowledge of either one or the other element. Therefore, SMEs should create a small, committed interdisciplinary team that works closely together with the selected partners to slowly build the internal capabilities around Artificial Intelligence. It can be beneficial to plan regular project reviews giving the AI experts the opportunity to exchange regularly with process experts and adapt the data to the goals. By experimenting, gathering feedback, and making necessary adaptations, employees gain valuable experience while still keeping the project pace high to ensure a timely ROI.

3.2. Choosing an AI engineering methodology

An AI engineering methodology provides valuable guidelines for small and medium manufacturers that want to create and implement such projects successfully. Choosing the right methodology is a critical step in the project development process and requires careful consideration of various criteria to match the SMEs' needs. A methodology that provides clear guidelines and efficient processes helps organizations to break down the complexity of AI projects into manageable tasks, thereby reducing the risk of project failures.

"AI Engineering Design is crucial in the corporate context as it empowers businesses to harness the power of artificial intelligence to drive innovation, enhance efficiency, and make data-driven decisions. By leveraging AI technologies, companies can unlock new opportunities, optimize processes, and gain a competitive edge in today's rapidly evolving digital landscape."

Prof. Dr. Kölmel
Hochschule Pforzheim & WFG Wirtschaftsregion Nordschwarzwald

3.2.1. Criteria for the selection of AI engineering methodologies

To provide decision support for selecting methodologies, the following analysis examines and evaluates three different methodologies in the AI Engineering landscape and is based on three distinct factors:

— **Organizational criteria:** Organizational criteria for the selection of AI engineering frameworks revolve around the interplay of AI systems, the organization as a whole and human factors in the organization.

AI engineering frameworks differ to the extent in which human resources are considered, such as the definition of different roles and responsibilities that are required. It is also necessary to analyze higher-level organizational changes that may arise due to AI projects and provide measures to steer them toward success of the AI project. Furthermore, different degrees of usability of AI engineering methodologies should be considered, including the flexibility of the methodology for application to various business circumstances. This is especially important for SMEs with varying levels of digital maturity, which have different requirements for such a methodology. Additionally, the ease of use of the methodology is a factor to consider, as complex projects require clear and concise guidelines and instructions.

— **Business criteria:** Various business criteria, including process duration, costs and the aim of the project determine the selection of an AI engineering methodology. The chosen method should support identifying and clarifying project aims, define its scope, and respond to the target user's needs, be it customers or employees. The process duration refers to the time it takes to transform an initial idea into a tested product or service, which is essential in the fast-moving AI industry, and differs among AI engineering methodologies. Moreover, costs associated with the AI project, including cost management strategies, are crucial factors to consider.

— **Technology criteria:** The technological instructions given by AI engineering methodologies encompass technical processes and decisions that significantly influence the success of an AI project. These instructions cover diverse topics, such as data collection and handling, application modeling, and deployment throughout the project's life cycle. Moreover, AI engineering methodologies should consider the necessity and guidelines for the right IT-infrastructure for AI projects to ensure the project's optimal technical performance and eventual success.

3.2.2. Three AI engineering methodologies worth considering

Below, three contrasting AI engineering methodologies are evaluated, with the tables in the appendix detailing their unique features, strengths, limitations and areas of application.

— **PAISE – Process Model for AI Systems Engineering:** PAISE is an AI engineering methodology that was developed in 2021 by Fraunhofer IOSB, FZI Research Center for Information Technology, and Karlsruhe Institute of Technology (KIT). At its core, it regards the development of AI applications as a larger system that can be broken down into subsystems, encompassing software and the interplay with hardware that generates data. The primary domain of application for PAISE is the manufacturing industry.

This framework is recommended for the development of complex new (hardware) products with AI capabilities. Its main strengths are a holistic view of hardware- and software-defined AI systems and checkpoint-based process structure, which tries to ensure adherence to requirements and project success. Its main weakness is the non-specific and limited guidelines, which require consultation with a PAISE expert. It also lacks thorough consideration of economic and change management-related factors necessary for a successful AI project.

— **TDSP – Team Data Science Process:** The Team Data Science Process (TDSP) is an agile and iterative data science methodology that Microsoft introduced in 2017. It offers a general approach for developing predictive analytics solutions and intelligent applications regardless of industry. Its use is recommended in well-defined use cases where the necessary data and programming competencies are available

The TDSP includes four major phases: business understanding, data acquisition and understanding, modeling and deployment. This methodology emphasizes a highly iterative approach at each step and clear and detailed technical guidance, enabling immediate execution of AI projects. Weaknesses are its limited consideration of organizational change, employee training and economic factors that are crucial for SMEs.

— **AI-M-SME – AI for Manufacturing SMEs :** In 2020, the ESB Business School (Hochschule Reutlingen) and the Fraunhofer Institute for Manufacturing Engineering and Automation IPA jointly published a pragmatic methodology that caters specifically to the needs of manufacturing SMEs looking to implement AI projects. In this paper, we will refer to this methodology as AI-M-SME (AI for Manufacturing SMEs). This methodology provides comprehensive guidance on the entire process, starting from the initial ideation phase, through the organizational and technical setup of the project, to the design, implementation, and monitoring of the machine learning solution. By covering the full spectrum of activities, this methodology ensures that manufacturing SMEs have the necessary support to implement AI projects successfully.

One of the unique features of AI-M-SME is its focus on embedding individual AI projects within a broader, company-wide strategy. This approach recognizes that SMEs cannot isolate AI projects from other parts of the organization and must integrate them with other strategic decisions. Although many important topics are considered, the depth of information provided is limited.

— **Combine methods to fit your needs:** The presented AI engineering methodologies serve different purposes, and it is crucial to know when to use which methodology to successfully implement an AI project. It is unlikely that a singular off-the-shelf methodology can satisfy every need of an SME. Therefore, it is advisable to consider methodologies as starting points for customization by combining multiple methodologies. For example, the AI-M-SME provides a holistic framework that considers the totality of business, organizational, and technological success factors. However, it lacks detailed technological instructions on the Machine Learning pipeline. To resolve this issue, one can pair AI-M-SME with TDSP's detailed instructions on technological aspects.

In summary, choosing the appropriate methodology for an AI project sets the foundation for the development and implementation of successful AI-based systems. Once you have done that, you will need to figure out how to convince the stakeholders in your company to maintain support throughout the whole AI project.

"Develop an AI strategy, find trustworthy partners and start with small projects to gather experience."

Gennadi Schermann
DIZ Digitales Innovationszentrum GmbH

3.3. Mitigating risks

The use of Artificial Intelligence in manufacturing offers significant benefits, including increased efficiency and effectiveness, improved decision-making, and the extraction of new insights from complex data. However, these benefits come with a range of risks and challenges that manufacturers must address to ensure that their use of AI is both effective and responsible.

— **Cybersecurity:** One of the most significant risks associated with AI in manufacturing is cybersecurity. AI systems are vulnerable to cyberattacks, which can result in the theft or manipulation of sensitive manufacturing data or even sabotage the manufacturing process. Hackers could potentially gain access to manufacturing systems and disrupt the production process, leading to downtime, lost revenue and reputational damage.

— **Data:** Another risk is data privacy. The use of AI in manufacturing can involve the collection, processing, and storage of personal data. This data can be vulnerable to unauthorized access or disclosure, which can lead to identity theft, financial loss, or reputational damage for both the manufacturer and individuals whose data is compromised.

— **Transparency:** The use of Artificial Intelligence in manufacturing can also introduce transparency risks, which can lead to errors, unfairness, or bias in decision-making. This can occur when AI systems make decisions based on complex algorithms and data sets that are difficult for individuals to understand or control. This lack of transparency can make it difficult to identify errors or bias in the decision-making process and may lead to unfair or discriminatory outcomes.

— **Internal:** Implementing AI in manufacturing presents not only technical challenges but also organizational risks that can impact the success of the initiative. One of the primary concerns is the potential resistance from employees who might view AI as a threat to their job security or as an overly complex tool that disrupts established workflows. Additionally, without clear communication and training, there can be a lack of understanding and trust in the AI systems, leading to underutilization or misuse. Furthermore, as AI projects often require significant investments, there's a risk of wavering stakeholder support if immediate returns are not evident. It's crucial to maintain consistent communication with stakeholders, highlighting both short-term wins and long-term benefits, to ensure sustained backing and alignment throughout the entire duration of the AI project.

To mitigate these risks, manufacturers can implement cybersecurity measures, develop data privacy policies, ensure transparency and fairness in decision-making, provide training and education to employees, and collaborate with experts to develop best practices.

3.4. Learning and creating an integrated strategy

Implementing AI might be different from other innovation projects, both technically and culturally. So, be sure to regularly reflect on your learnings and share them within the organization. Each time you do that, you create AI capability for the whole business rather than just a new tool for one specific team. And you pave the way for a company-while, holistic Artificial Intelligence strategy. Below you can find a handy overview of dos and don'ts based on extensive hands-on experience from the first three years of the AI4SME program.

Dos

Strategic Planning

— Define a clear project scope with in-scope and out-of-scope deliverables
— Test and learn for a larger vision and strategy
— Set smart targets: identify manageable use cases for your business
— Focus on defined objectives first and manage the expectations of the stakeholders
— Make sure that project risks are identified and acceptable

Collaboration

— Collaborate within your organization, with partners from academia and business
— Consider collaborating with your competitors
— Use regional ecosystem networks for knowledge exchange and find partners and experts

Data and Workload Management

— Plan ahead for collecting and cleaning the data
— Define information security and data protection measures
— Find the balance between daily workload and AI project (production comes first!)
— Define your goals and strategy before storing data

Don'ts

Project Management

— Don't make the project scope too large
— Don't underestimate the workload needed for the AI project
— Don't start the project without the right people and talent in place
— Don't forget about ethics and security measures
— Don't reinvent the wheel, use existing tools and platforms

Organizational and People Development

— Don't forget about training your employees
— Don't miss events to interact, share best practices and learnings
— Don't underestimate the organizational coordination between departments

Expectation Management

— Don't overestimate the current state of AI and Machine Learning
— Don't expect AI accuracy to be sufficient in the first run

4. Conclusion: Embrace the AI Revolution in Manufacturing

In the dynamic landscape of manufacturing, SMEs in the trinational region of Baden-Württemberg, Germany, Basel Area, Switzerland, and Grand Est, France stand at a pivotal juncture. The transformative power of Artificial Intelligence offers a beacon of innovation, promising not only to streamline operations but also to open new avenues of growth. As we have outlined in this white paper, the potential benefits of AI are vast, from operational efficiency to product quality assurance and the creation of new business opportunities.

However, the journey to AI adoption is not without its challenges. Skepticism, resource constraints, and the sheer pace of technological evolution can be daunting. Yet, the regional support structures, combined with a pragmatic framework, provide a roadmap for SMEs to navigate these challenges. By understanding the potential risks, ensuring robust cybersecurity measures, and fostering a culture of continuous learning, SMEs can harness the full potential of AI.

In conclusion, the future of manufacturing in the trinational region is intertwined with the advancements in AI. By embracing this revolution, SMEs can not only ensure their competitiveness but also shape the future of manufacturing on a global scale.

5. Appendix

5.1. PAISE®

	Fulfillment of Business Criteria	Fulfillment of Organizational Criteria	Fulfillment of Technological Criteria
Strengths	The methodology provides a framework for the definition of project goals and requirements. Risk management is inherent through regular checkpoints, ensuring timely detection and resolution of issues. Cost and time monitoring is supported but not explicitly specified. Parallel work packages promote time efficiency.	PAISE provides a framework for the definition of roles and responsibilities. The methodology is user-friendly due to guiding questions, result expectations and examples for each phase.	Methodology includes brief guidelines for data sourcing. PAISE includes guidelines to deploy the system, to monitor and improve it in the aftermath.
Weaknesses	Economic aspects are not thoroughly considered. Effective project management is missing. PAISE assumes that the use case for the AI application is already defined, and all the stakeholders' needs are known.	Change management aspects are not considered. PAISE provides relatively high-level information. It lacks a self-explanatory, granular action plan and cannot be carried out without consulting with experts.	Limited explanation of the actual steps of the machine learning pipeline such as data pre-processing, Machine Learning modelling and deployment. PAISE assumes that hardware and IT infrastructure already exist to collect and provide data.

5.2. TDSP

	Fulfillment of Business Criteria	Fulfillment of Organizational Criteria	Fulfillment of Technological Criteria
Strengths	The methodology supports the definition of project goals and requirements. Agile development and systematic project management are incorporated, allowing for efficient time monitoring.	TDSP provides a self-explanatory granular action plan for the whole project, making it immediately executable. The methodology is user-friendly, offering ready-to-use templates for deliverables. Roles and detailed responsibilities with interdependencies across the project lifecycle are defined.	Detailed suggestion of directory structures for storing accumulating files and data. Provides extensive recommendations for the IT infrastructure stack (with a bias towards Microsoft Azure services to leverage maximal advantages. However, Azure can be interchanged with the cloud provider of choice.) TDSP offers detailed explanations of the actual steps of the Machine Learning pipeline such as data pre-processing, ML (Machine Learning) modelling and deployment.
Weaknesses	Economic aspects are not thoroughly considered. TDSP assumes that the concrete use case for AI application is defined and all stakeholder needs are known.	Change management aspects are not considered.	TDSP assumes that hardware and IT-infrastructure already exist to collect and provide data.

5.3. AI-M-SME

	Fulfillment of		
	Business Criteria	**Organizational Criteria**	**Technological Criteria**
Strengths	AI-M-SME includes consideration of economic viability and cost controlling as integral parts of the process. Risk management is inherent in the methodology as it suggests approaching the final solution through small-scale prototypes. The methodology includes guidance on the best approaches for insourcing expertise that may not be available in-house.	The methodology provides a framework for the definition of roles and responsibilities. Project goals are systematically defined based on desired technical and business improvements, economic factors, and feasibility. AI-M-SME emphasizes a user-centric approach, with guidance on aligning AI systems to actual user needs. Employees involved in the project receive specific AI training, and a companywide understanding of AI and its potential is established.	The methodology provides general ideas for data sourcing, indicating measures to obtain data from machines in different circumstances. The landscape of ML infrastructure alternatives is presented and decision factors for the selection are briefly described.
Weaknesses	Effective project management is missing.		AI-M-SME provides limited explanations of the steps of the Machine Learning Pipeline such as data pre-processing, ML modelling and deployment.

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About Basel Area Business & Innovation

Basel Area Business & Innovation is a non-profit agency dedicated to helping startups, institutions and companies find business success in the Basel Area. As an independent organization funded by the cantons of Basel-Stadt, Basel-Landschaft and Jura, as well as by the Swiss government and private foundations, we help develop a robust business climate and support innovative ventures. We attract and support companies moving into the area, connect organizations and entrepreneurs with collaboration partners, and help create a vibrant ecosystem that fosters innovation.

About Industrial Transformation

In today's ever-changing technological world, manufacturing companies are continuously challenged to transform themselves to adapt to the evolving needs of their customers and to the evolution of the digital technologies. This requires new core skills, capabilities and a lot of work to find for example the best suitable business model.

The Basel Area Industrial Transformation initiative offers a powerful ecosystem for tackling the transition of the manufacturing industry towards smart technologies and sustainable production methods. The Initiative offers a collaborative platform with events, catalyst projects within the broader Basel Area (Upper Rhine including France and Germany), and is host of the multifaceted i4Challenge program, to accelerate the development of startups, SMEs and new ideas in the field of Industry 4.0.

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