INSIGHTS VOLUME 01 NOVEMBER 2024

AMACADEMY
powered by AMPOWER

Scaling Additive Manufacturing

A comprehensive strategy for successful implementation

INSIGHTS GAINED

What is my organization's Additive Manufacturing maturity?

How can I increase the maturity of AM in my organization?

What are different ways to increase AM knowledge of my employees?

Benjamin Haller

MANAGING DIRECTOR AT AM ACADEMY

Additive Manufacturing has come a long way from the early days where it was primarily used as a prototyping technology. Today, we can see impressive examples of AM applications that are marking a substantial impact across a range of industries, from aerospace to oil & gas. However, despite these advancements, many of these initiatives remain confined to pilot projects, and only a select few organizations have fully integrated AM into their operations.

Even in the most advanced companies, a limited number of employees possess the expertise necessary to harness the full potential of Additive Manufacturing. For the technology to truly scale and drive meaningful, sustainable impact, it is inevitable that a much broader group of employees is equipped with the necessary skills and knowledge.

We firmly believe that education is a critical component in advancing Additive Manufacturing sustainably. By fostering a culture of learning and equipping teams with the right tools and insights, organizations can unlock the transformative power of this technology, driving innovation and growth in a responsible and impactful manner.

Management summary

Despite the growing number of success stories in Additive Manufacturing (AM), many companies still struggle to adopt the technology effectively and sustainably. While an increasing number of companies manages to identify use cases for end use components managed through central expert departments, the widespread use of AM for serial applications and parts that are thought for AM from the beginning requires a wider approach implementing the technology.

One challenge many companies are facing is that they do not manage to fully implement their AM strategy due to a lack of a tangible roadmap. This leads to limited impact of AM and thus companies struggle to justify continuous investments into the technology.

A second challenge lies in the widespread dissemination of AM knowledge. While some organizations have successfully established 'expert centers'- typically consisting of a small team of AM experts tasked with defining the role of the technology in their business, few managed to extend this knowledge to a broad range of employees. This hinders the ability not only to implement a company-wide AM strategy, but also to unlock the full potential of AM across all levels of the business, including the product and process chain.

The AM Academy outlines a strategic approach for the successful implementation of Additive Manufacturing, starting with a self-assessment of the organizational AM maturity across key business functions. A concrete roadmap to increase the maturity in each of the areas is then presented, putting a clear focus of increasing the knowledge of key employees. Finally, alternative means to gain knowledge and insights are presented and demonstrated with success stories

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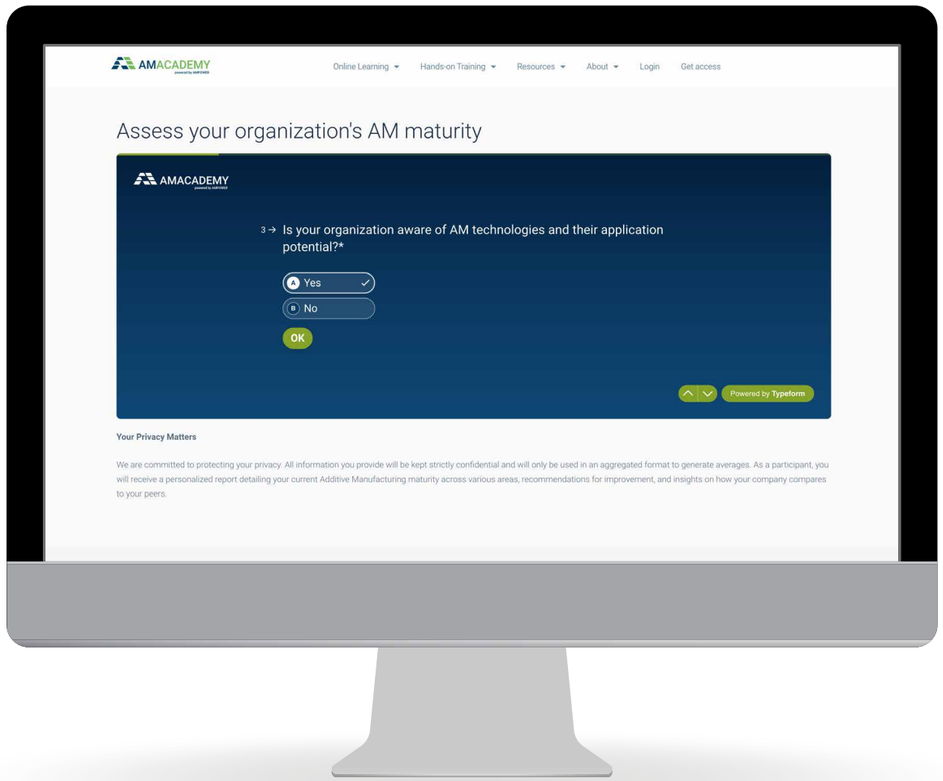


Content

ABOUT AMPOWER

AMPOWER is the leading strategy consultancy and thought leader in the field of industrial Additive Manufacturing. The company advises investors, start-ups as well as suppliers and users of 3D printing technology in strategic decisions, due diligence investigations and provides unique access to market intelligence. On operational level, AMPOWER supports the introduction of Additive Manufacturing through targeted training programs, support in qualification of internal and external machine capacity and technology benchmark studies. The company was founded in 2017 and is based in Hamburg, Germany, operating worldwide.

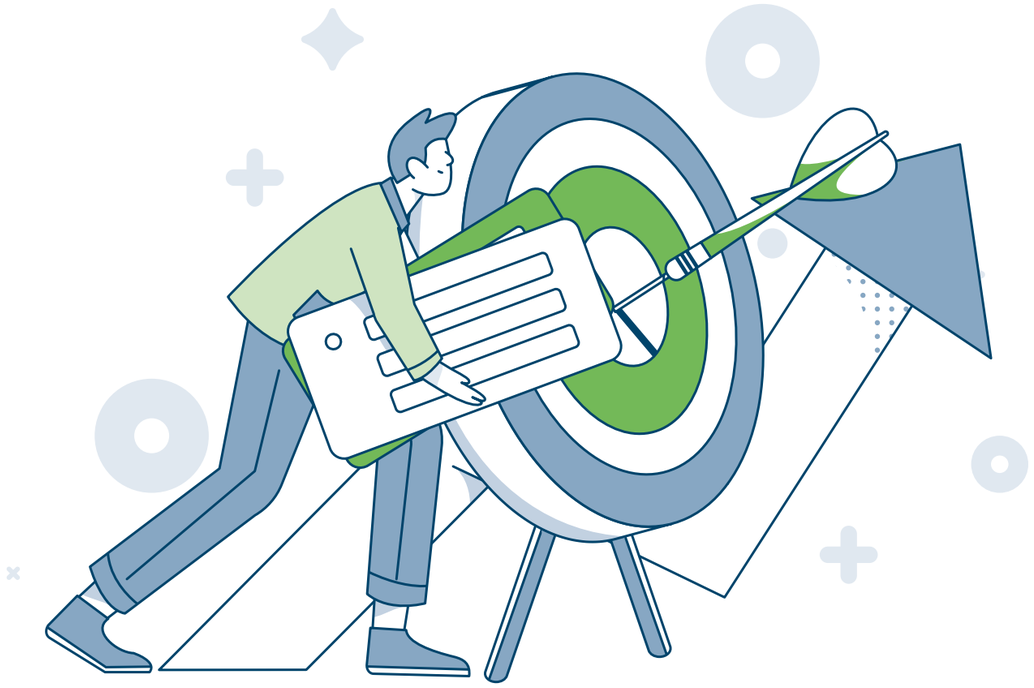
ABOUT AM ACACEMY

AM Academy offers independent Additive Manufacturing education services and is powered by AMPOWER. The company collaborates with end users to support them in the definition and implementation of their AM strategy using online learning courses, live trainings and guided programs. The AM Academy is supplier-agnostic and encompasses all Additive Manufacturing technologies, emphasizing hands-on, industry-relevant content. The company was founded in 2024 and is based in Hamburg.

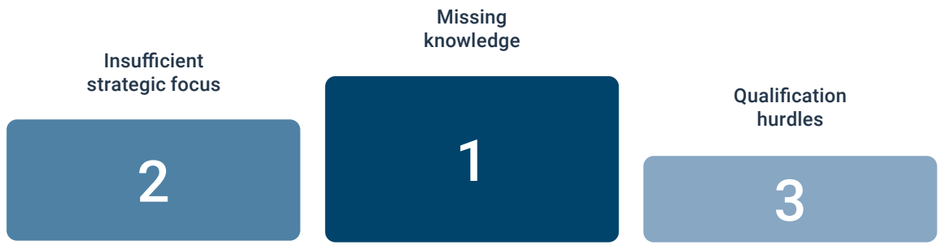
Introduction

Companies struggle to scale AM due to a lack of strategic focus and limited organizational knowledge

A structured approach to build up knowledge and increase organizational AM maturity can help create tangible value of the technology.



Top reasons for a slow AM implementation



Additive Manufacturing has captured the interest of many industries with its potential to revolutionize production processes, yet its widespread adoption remains a challenge for many companies. While early applications of AM focused on prototyping and small-scale pilot projects, the real value of this technology lies in its ability to be scaled up for serial production and incorporate it into the core of business operations. Even though the days when AM was mostly use as a prototyping technology are over and end use and spare parts are now the predominant application category, the implementation is far from completed across all industries.

Moving from isolated success stories to fully integrated, company-wide use of AM requires more than just technological know-how—it demands strategic foresight and organizational alignment. For many organizations, the transition to widespread AM implementation is slowed by the absence of a clear and cohesive AM strategy. Without a well-defined roadmap that aligns with the company's broader corporate objectives, it becomes difficult to measure the full impact of AM on business outcomes and to justify ongoing investments.

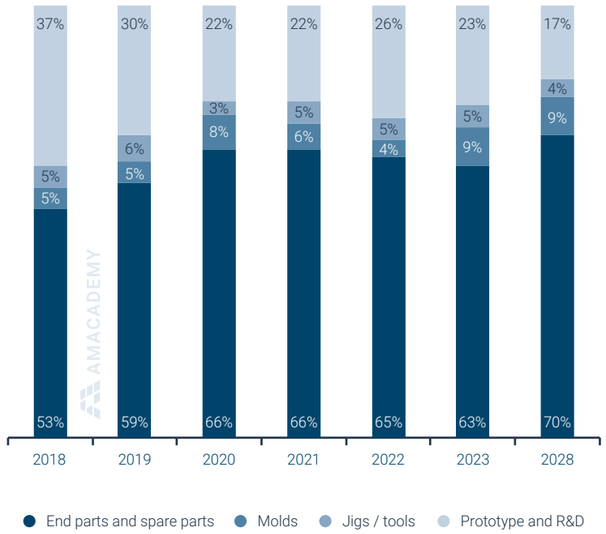
In addition, many companies struggle to disseminate AM expertise across the workforce, leaving it confined to specialized departments or 'expert centers.' This siloed approach prevents organizations from realizing AM's full potential in transforming products, processes, and even business models.

AM ACADEMY provides a strategic framework for overcoming these common barriers and achieving successful, sustainable AM implementation. It addresses key challenges such as aligning AM with corporate strategy, building organizational knowledge, and fostering company-wide engagement to ensure that AM delivers maximum value across all levels of the business.

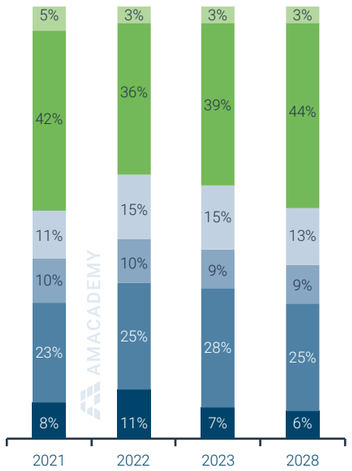
The foundation of this framework is the Organizational AM Maturity Assessment, which any company can complete independently. Once the assessment identifies key focus areas for growth, this whitepaper outlines clear guidelines to progress in each domain through different learning strategies as well as alternative approaches to grow maturity.

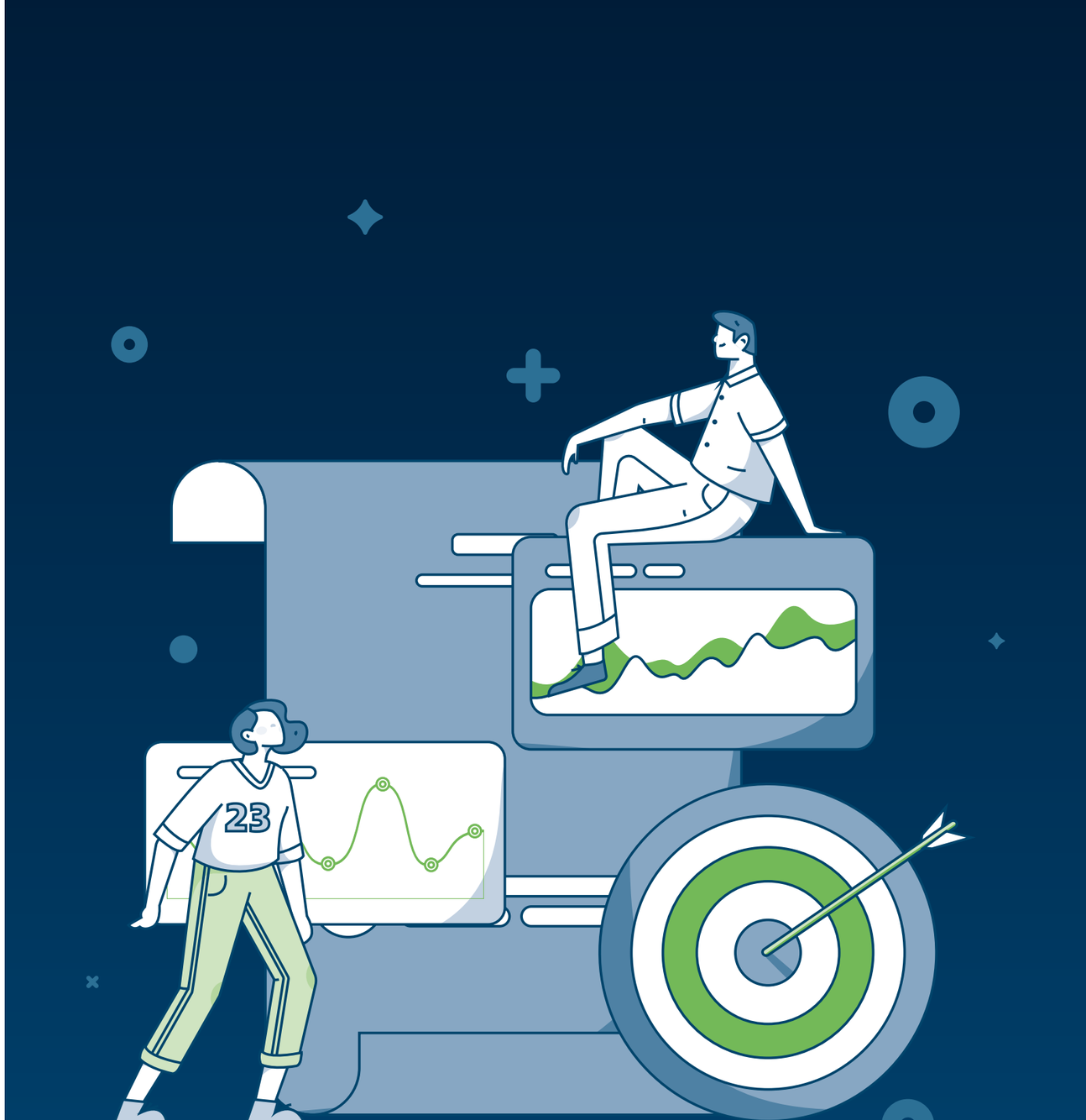
AMPOWER Report 2024

Application category of printed metal parts 2018 to 2023 and forcast 2028



Application category of printed polymer parts 2021 to 2023 and forecast 2028





End-to-end integration of Additive Manufacturing

The adoption of AM affects nearly every business function, from strategy and product development to supply chain and procurement, due to its highly transformative nature and the wide-reaching changes it introduces across traditional operational processes.

The introduction of new technology into an organization is a transformative process that can redefine operational practices, create new opportunities, and drive innovation. Independent of the technology, the adoption typically follows a series of steps, including evaluating potential benefits, addressing initial resistance, and eventually integrating the technology into standard workflows. This process often involves adapting business processes, retraining employees, and realigning strategic goals to accommodate the new technology's capabilities.

In the case of Additive Manufacturing, the implementation process is particularly distinctive and impactful. Unlike other manufacturing processes, AM is inherently disruptive, with the potential to fundamentally alter business models, products, and supply chain dynamics. The technology's ability to produce complex, customized parts with reduced material waste introduces a wide range of implications that extend beyond traditional production and quality assurance. The integration of AM thus requires a broad perspective, considering its effects on design, engineering, strategy, and supply chain management.

To address these complexities comprehensively, we categorize the critical areas involved into five primary domains:

Strategy

Product & Design

Technology & Engineering

Standards & Qualification

Supply Chain & Purchasing

Each domain plays a critical role in ensuring that AM is effectively integrated into the organization, maximizing its benefits and achieving a seamless transition from traditional manufacturing methods.

While depending on a company's industry and strategic focus it might be natural to have a stronger focus on 1-2 of these areas, it remains important to gain maturity across all the domains over time.

Strategy

Implementing AM necessitates a strategic vision that aligns with the company's long-term goals and competitive landscape. This involves identifying how AM can create value, drive innovation, and support business objectives. The strategy should encompass setting clear goals, assessing market opportunities, and allocating resources effectively to support AM initiatives.

Product & Design

The integration of AM impacts both product development and design processes. It starts by evaluating which products or components are best suited for AM. Next is optimizing product designs for AM, exploring opportunities for customization, performance improvement, and adjusting the design to meet technology requirements. Effective product and design strategies ensure that the advantages of AM are fully realized in the development of new and existing products.

Technology & Engineering

Based on the chosen products and components comes the selection and implementation of AM technologies and their integration into engineering practices. It includes evaluating and choosing the appropriate AM machines, materials, and software based on the specific needs of the organization. Engineering processes must be adapted to incorporate AM-specific considerations. This ensures that the technological infrastructure and engineering workflows are optimized to support efficient and effective AM production.

Standards & Qualification

To ensure the quality and reliability of AM parts, establishing rigorous standards and qualification processes is essential. This involves developing and adhering to industry standards for AM, conducting thorough testing of AM parts, and implementing quality control measures. It includes establishing protocols for part qualification and performance verification to ensure that AM-produced components meet required specifications and function reliably in their intended applications.

Supply Chain & Purchasing

Integrating AM into production processes requires a thoughtful approach to supply chain management and purchasing. This covers sourcing and managing materials and parts and qualifying and coordinating with suppliers. It also involves addressing logistical challenges and developing procurement strategies that align with AM's unique production requirements.

Self-evaluation

Organizational AM maturity

Assessing an organization’s current maturity across the entire business is key to move forward with the integration of Additive Manufacturing.

To increase the maturity of AM in an organization, it is crucial to first assess the status quo. This step evaluates readiness and capabilities across the previously defined domains, providing insight into the company's current position in AM adoption.

Based on experience, companies go through 4 distinct phases on their way to adopt Additive Manufacturing:

1. **Exploration:** Early experimentation with different technologies & trying out use cases.
2. **Implementation**: First projects are being implemented in key areas.
3. **Expansion**: Translation of successful projects into an increasing number of departments.
4. **Scaling:** Strategic and structured scaling of AM globally, across all affected business functions.

An organization’s maturity can be assessed using a set of guiding questions that are outlined on the following pages. A maturity level in a given domain is achieved once at least 2 out of 3 questions can be answered with yes.

This framework offers a systematic way to assess maturity in each domain, enabling companies to understand both internal progress and industry benchmarks. This comparison helps identify areas needing improvement, allowing for targeted actions to stay competitive in adopting AM technologies.

The levels of organizational AM maturity

LEVEL 1

Exploration

The organization is at the early stage of AM adoption, experimenting with technologies and applications, but without formal strategies or structures. Initial efforts are focused on learning and assessing AM´s potential applications.

Typical Products:
Prototypes

LEVEL 2

Implementation

The company has established foundational AM strategies and processes. AM is being implemented in specific areas or departments, and formal procedures for production and qualification are being set up. Teams are starting to receive relevant training and basic supply chain adaptations are underway.

Typical Products:
Jigs & Fixtures | Part substitution
"Lighthouse" projects

LEVEL 3

Expansion

AM is now expanding beyond the initial departments or projects, reaching more areas within the organization. Crossfunctional teams are increasingly involved, and the company is optimizing its internal processes. AM capabilities are spreading into new products, business units, and strategic partners.

Typical Products:
Spare parts | Part optimization
End-use parts

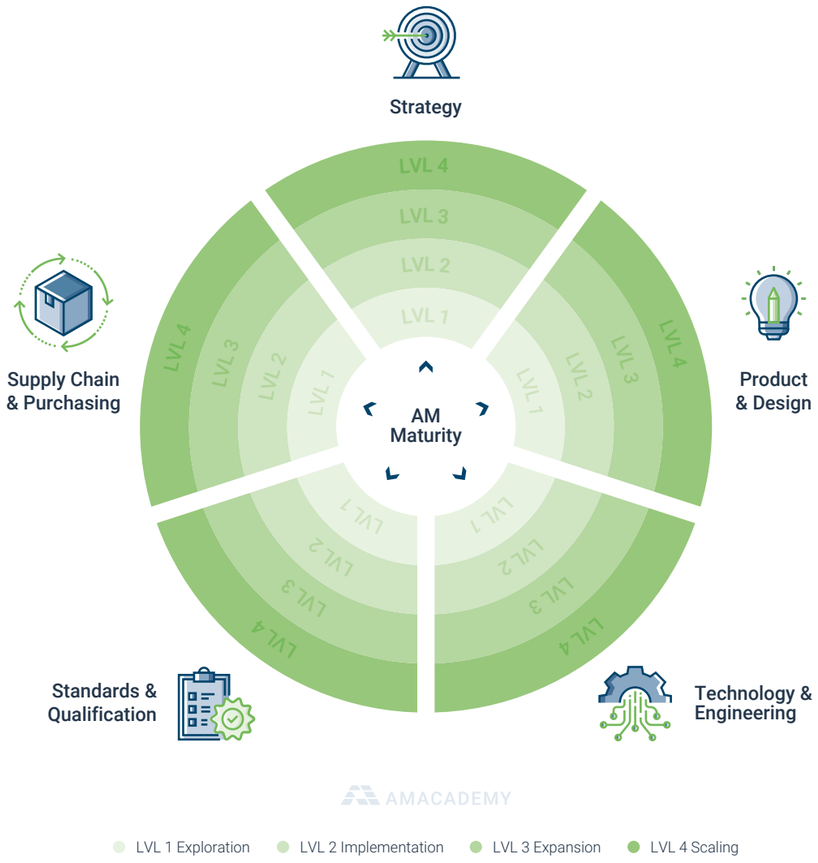
LEVEL 4

Scaling

AM is deeply embedded within the organization, with robust, standardized processes in place across all relevant departments. The company has scaled its AM operations globally. AM is fully optimized, contributing to innovation and growth, with a focus on continuous improvement and competitive advantage.

Typical Products:
"AM-only" designs | Qualified & critical components

Assess your organizati-on's AM maturity



Test your AM maturity* in the field of "Strategy"

LEVEL 1

Exploration

No AM strategy defined

- ☐ Is your organization aware of AM technologies and their application potential?
- ☐ Have the potential impacts of AM on your core business been discussed?
- ☐ Is there a leadership or management commitment to exploring AM?

LEVEL 2

Implementation

Impact of AM understood

- ☐ Have you identified key areas where AM could impact your business?
- ☐ Are there specific goals or metrics related to AM adoption?
- ☐ Is a dedicated team responsible for piloting AM initiatives?

LEVEL 3

Expansion

AM impact quantified

- ☐ Has the impact of AM been quantified and is measured across relevant business areas?
- ☐ Is AM integrated into your long-term strategy and planning?
- ☐ Do different departments (e.g., R&D, production) actively collaborate on AM projects?

LEVEL 4

Scaling

Clear company-wide strategy

- ☐ Is there a company-wide AM strategy that is regularly reviewed and updated?
- ☐ Are AM goals aligned with overall business objectives across all departments?
- ☐ Is AM seen as a key enabler of innovation and competitiveness in your strategy?

FOR THE FULL ASSASEMENT VISIT:
www.additive-manufacturing-training.com/maturity/

*2 CHECKMARKS TO COMPLETE EACH LEVEL

Move your company forward

Building expertise to increase maturity

A hybrid learning path to develop AM expertise and advance organizational maturity across all domains.

After assessing the current Organizational AM Maturity, the next step is to enhance maturity across various domains. Special attention should be given to those with lower maturity levels. Each domain has a specific development path outlined in the following pages. To cultivate these skills, a hybrid training approach that combines various learning methods is recommended:

- **Online Learning: Builds a foundational understanding through cost-effective, flexible courses.**
- **Live Trainings & Workshops: Offers hands-on experience for prototyping and lighthouse applications.**
- **Guided Programs: Structured and applied programs to implement AM for concrete projects.**
- **Consulting: Delivers tailored advice to optimize strategies and fully integrate AM into the business.**

These methods build progressively, starting with online learning to educate a wide audience, and culminating in consulting and advanced projects for expert-level and company-specific knowledge.

Each domain requires key employees to lead AM activities in their area, with the overall process being overseen by a core AM expert center, ideally composed of representatives from all domains.

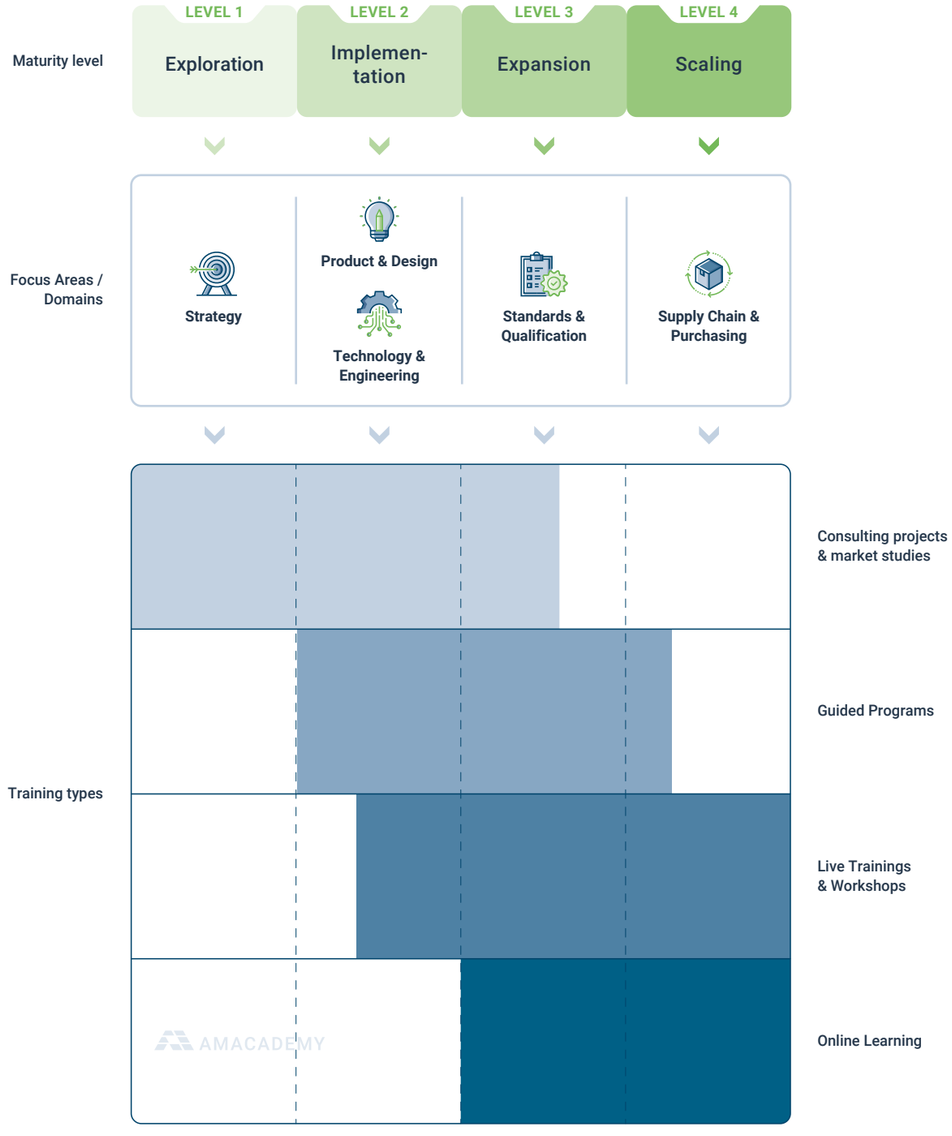
As an organization's AM maturity increases, its knowledge base deepens and at the same time the number of employees with AM expertise grows. Expertise grows more robust over time, but training a larger number of employees in AM fundamentals remains critical. Even among advanced AM users today, most designers and professionals still lack adequate AM skills. While a small group of specialists may be enough in the early stages, a more mature company will need a broader team - including designers, operators, managers, and purchasers - to understand the technology's basics.

With increasing maturity, all 4 of these learning methods should thus be combined with each other. In addition to conventional learning methods, alternative strategies such as attending trade fairs, joining networks, and organizing internal AM competitions offer low-cost, effective ways to boost organizational maturity.

Key employees to be trained by domain

Strategy	C-Level Executives (e.g., CTO, COO) | Business Development Managers Department Heads
Product & Design	Product Designers & Design Engineers | R&D Engineers | Application Engineers
Technology & Engineering	Machine Operators | Process Engineers | Materials Scientists
Standards & Qualification	Quality Assurance Managers | Certification Specialists | Manufacturing Engineers
Supply Chain & Purchasing	Procurement Managers | Supply Chain Managers | Logistics Coordinators

Training type depending on organizational maturity level



The road to AM maturity

Domain	LEVEL 1 Exploration
Strategy	**Identify strategic AM opportunities** • Evaluate AM's potential business impact • Analyze customer pain points • Study industry and competitor AM usage
Product & Design	**Find early AM applications** • Select non-critical parts for AM • Train designers in fundamental AM skills • Build initial trust in AM
Technology & Engineering	**Explore AM technologies** • Identify technology need based chosen products • Research available AM technologies • Try out and test technologies
Standards & Qualification	**Research AM standards** • Review industry-specific AM standards • Identify gaps in current processes • Select applicable standards for AM
Supply Chain & Purchasing	**Explore supplier network** • Identify AM suppliers • Build initial supplier relationships • Understand how to identify suitable AM parts

COMPLETE THE AM MATURITY ASSESSMENT TO RECEIVE A CUSTOMIZED REPORT:

www.additive-manufacturing-training.com/maturity/

Building skills beyond standard training concepts

A hybrid training approach, as outlined in this whitepaper, lays the groundwork for elevating your organization's AM maturity. Beyond traditional training, several other initiatives can further enhance knowledge and maturity.

1 Attend Additive Manufacturing fairs

Visiting AM fairs is crucial for skill-building. Encourage a broad range of employees — designers, managers, purchasers, and other professionals — to attend major events like Formnext, IMTS, Rapid TCT, and AMUG. Smaller fairs can provide specialized knowledge and help expand local networks.

2 Leverage suppliers

Many AM technology providers, including machine OEMs and software suppliers, have dedicated training departments and offer specialized training programs. These sessions are particularly valuable to build advanced and expert-level skills. Beyond trainings, suppliers can support you in applying your knowledge to specific projects.

3 Adopt AM software

Implementing AM software for part identification, evaluation, and sourcing helps build knowledge within your organization. It allows you to define qualified technologies and suppliers and share these insights across teams, driving greater organizational AM maturity.

4 Create internal AM competitions

Organizing internal AM design or innovation competitions can engage employees across departments, encouraging them to apply their knowledge in creative ways. These events foster a culture of learning, collaboration, and innovation while highlighting practical applications of AM within your organization.

5 Engage in networks and collaborations

Partnering with external research institutions, universities, or industry associations can provide access to cutting-edge AM knowledge and technology. Collaborating on joint projects or research helps your organization stay ahead of industry trends and accelerates learning across teams.

6 Establish knowledge sharing platforms

Implementing an internal platform where employees can share AM insights, case studies, and best practices promotes continuous learning. This could include an internal wiki, forums, or regular AM-focused newsletters, allowing team members to stay updated on new developments and success stories.

Elevate your team's skills with us

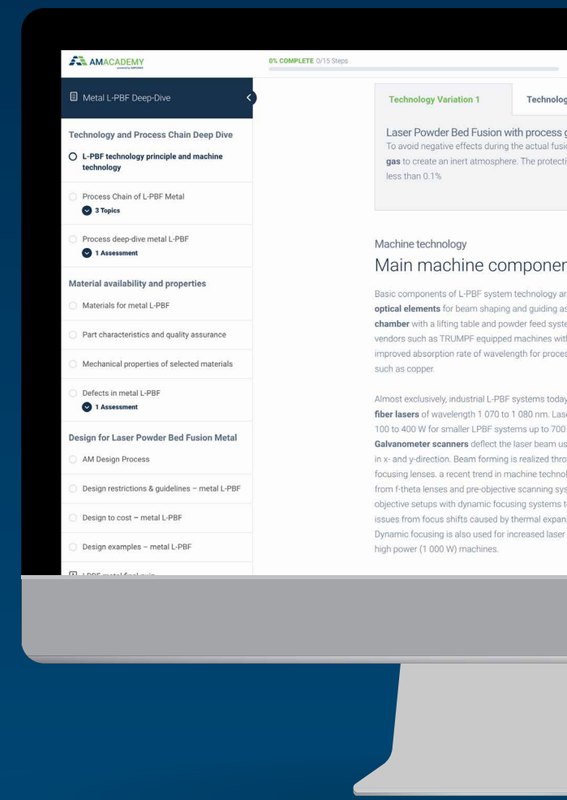
Discover our AM online learning courses:

- **Self-guided online learning courses with interactive videos**
- **Strong industrial focus and coverage of all relevant AM technologies & industries**
- **Wide range of courses for beginners and advanced users**

Courses can be combined with hands-on, customized live trainings as well as concrete projects into guided programs.

Currently available online courses:

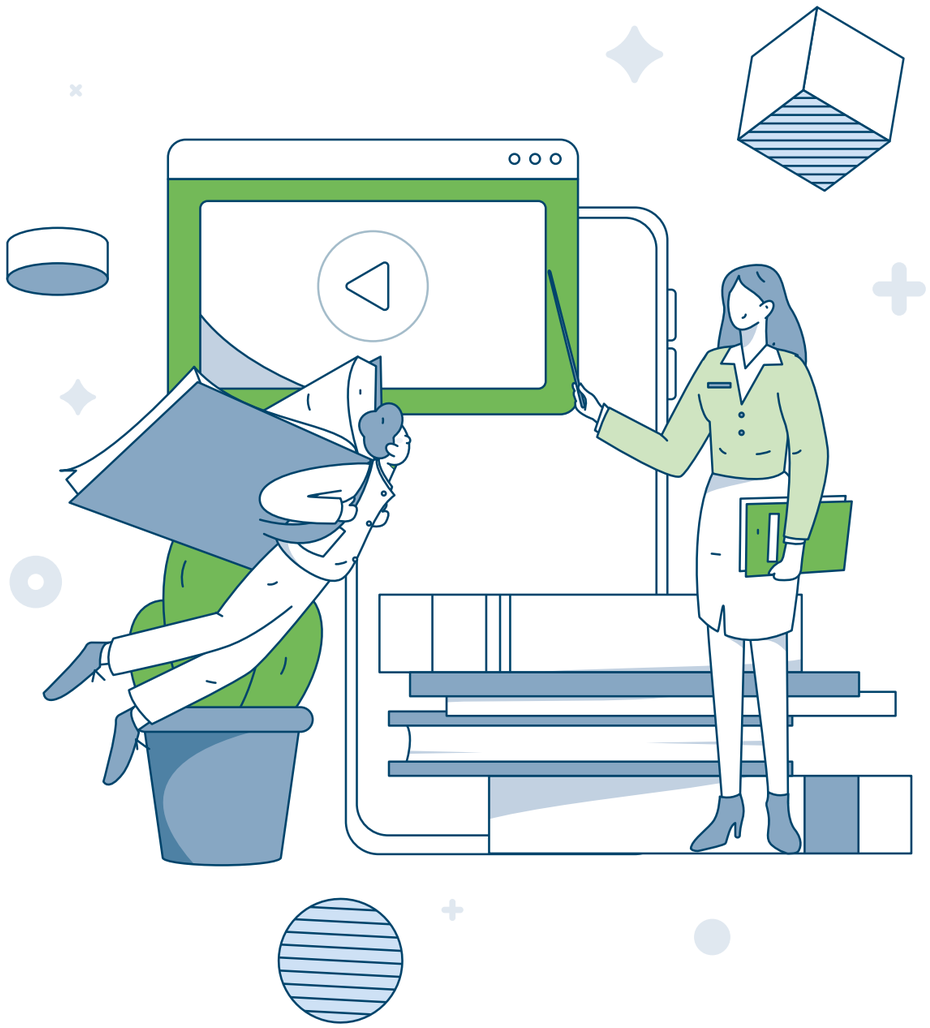
- **AM Fundamentals**
- **Metal Technologies**
- **Polymer Technologies**
- **Part Identification**
- **Cost calculation metal**
- **Metal laser powder bed fusion deep dive**
- **Sinter-based AM deep dive**



AM ACADEMY ONLINE LEARNING POWERED BY AMPOWER AVAILABLE AT:

https://additive-manufacturing-training.com/

Sucessful industry cases



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Learnings from successful end users

Get engaged - internally and externally. @Deutsche Bahn

One of the most important learning for Deutsche Bahn is engagement. First, there is internal engagement with all relevant stakeholders. From engineering, quality management and maintenance staff to management. With specific applications that solve pressing problems, ensure vehicle availability, and may also save money, stakeholders can be convinced to further support the project or even get involved themselves. This starts with training and ends with internal, company wide marketing of success stories. While engineering and maintenance are triggered by applications that solve technical issues, management can be convinced by reduction of downtime during maintenance and cost savings, direct and throughout the lifecycle. Both areas are heavily addressed by the 3D printing applications which Deutsche Bahn has developed. The ideas for such applications often come from DB's own employees who submit their printing suggestions, motivated by their own 3D Printing Competition.

But engagement also has an external component. Especially for companies, that cover multiple technologies and do not look at serial production of one single component, a vast network of partners can be vital for success. Especially exchanging with companies that have similar use cases can be extremely helpful. For Deutsche Bahn, those partners were found in other rail and mobility companies which led to the foundation of the Mobility goes Additive association. Topics that one single company can hardly cover such as materials, norms and standards are fast-tracked through this unique network in Europe.

DEUTSCHE BAHN 3D PRINTING COMPETITION.
COURTESY OF DEUTSCHE BAHN

Establish a selection of pilot projects that solve today's problems early on to focus qualification efforts. @Eaton Aerospace

One aspect, that is seen critical for this success at EATON AEROSPACE, is a clear 3D Printing strategy for added value. 3D Printing has no end by itself, but rather needs to provide added value in 4 different categories, that were established in the strategy:

- **Reduced development time thus earlier go to market**
- **Improved part performance such as optimized packaging, reduced weight, pressure drop (hydraulics) or improved heat management**
- **Reduced cost**
- **Increased sustainability (environmentally and supply chain resilience)**

With this added value centric approach, the EATON AEROSPACE Management was deeply involved and committed regarding the implementation of 3D Printing and the necessary monetary and capacity investments.

This strategy also involves a long-term commitment. It was clear from the beginning, that the success in 3D Printing does not come overnight but rather must be worked on for several years and the resulting applications today prove, that EATON AEROSPACE was very successful with this long-term approach.

Besides Management, the strategy also serves engineering as a guidance and motivation. Especially by solving today's problems with 3D Printing and increasing performance of components is what increases awareness and support in engineering. Many companies in highly regulated industries such as Aviation or Medical still struggle because of a historically risk-averse engineering department. With this value-add centric 3D Printing strategy, EATON AEROSPACE was successfully involving all relevant stakeholders from senior management, product management, quality management and engineering.

FUEL JET PUMP.
COURTESY OF EATON AEROSPACE

Learnings from successful end users

Complexity is free but not free of charge. 3D Printing Knowhow is key. @TRUMPF

While the slogan “complexity is for free” is often associated with 3D Printing, it is important to note that this technology can be expensive if the design is not well thought through. By educating engineers on how to design for 3D Printing, TRUMPF has been able to unlock the full potential of this innovative technology. However, it’s not just engineers who can benefit from a basic understanding of 3D Printing. Procurement teams, for example, can also identify potential applications where 3D Printing can help solve supply chain or quality issues.

Similarly, technicians and quality engineers on the shop floor or in process development departments can identify areas where 3D Printing can improve production processes or solve quality issues. For example, they may identify parts that are difficult or expensive to produce using traditional manufacturing methods or have continuing quality issues.

Overall, by empowering key personnel with an understanding of 3D Printing, TRUMPF has been able to unlock its full potential and create new opportunities for innovation and cost savings. This has helped the company stay ahead of the curve in a highly competitive industry and continue to deliver value to its customers.

3D PRINTED OPTICS SUPPORT PLATE AND CARRIER: RE-DESIGN LED TO WEIGHT REDUCTION, IMPROVED DEFLECTION AND COST SAVINGS. IMAGE SOURCE: TRUMPF

Choose the right suppliers that fulfil the required quality and price level. @BOBST

While BOBST invested in their own machines for metal and polymer 3D printing early on, they were continuously working with external suppliers for selected applications. The focus was initially on suppliers delivering high-quality parts. This strong focus on quality also meant that parts came at a high price. Over the years, additional suppliers with a stronger focus on costs have been onboarded, which ultimately leads to more successful business cases. Suppliers are now selected from a bigger pool based on specific application requirements.

3D PRINTING WORKSHOP. COURTESY OF BOBST

About the authors

Benjamin Haller

MANAGING DIRECTOR AT AM ACADEMY

Benjamin Haller specializes in guiding companies to successfully implement and benefit from Additive Manufacturing. He has worked with end users across several industries to support them in setting their AM strategy and implementing AM. With experience in a wide range of metal and polymer AM technologies, Benjamin has trained countless professionals, including designers, managers, and others, empowering them to innovate and grow.

Matthias Schmidt-Lehr

MANAGING PARTNER AT AMPOWER

Matthias Schmidt-Lehr successfully managed countless projects in Additive Manufacturing with focus on part screening, business case development, AM design optimization and production in both metal and plastic materials. With a history in the consulting business, he can provide a systematic approach to strategy development and scenario analysis. In his former positions Matthias gathered experience in business development, customer relationship management, as well as marketing and sales.

Dr.-Ing. Eric Wycisk

MANAGING PARTNER AT AMPOWER

Since 2008 Eric successfully supports OEMs from aerospace, medical and automotive to identify Additive Manufacturing applications and implement production capacities in their regulated environments. With a background in topology optimization, titanium alloys and fatigue he is focused on achieving the maximum part performance with the right AM technology.

Corporate responsibility

AM Academy compensates all CO2 emission produced by its daily operation, travel activities and digital data storage. By using ATMOSFAIR, a verified non-profit organization, to offset our carbon footprint we are actively supporting renewable energy and emission reduction projects in developing countries.

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