AMPOWER INSIGHTS

Additive Manufacturing **Business Strategy**

Be successful with
Additive Manufacturing

INSIGHTS GAINED:

- Overview on major strategic decision factors
- In depth supply chain strategy guide
- Detailed user strategy approach

Vol. 5
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Insights gained

Overview on major strategic decision factors
In depth supply chain strategy guide
Detailed user strategy approach

Management summary

The metal Additive Manufacturing market is a niche compared to the global market of metal products. However, the potential future market volumes are promising, and many companies are currently in the phase of market entry evaluation. Ampower Insight Vol. 5 presents an overview on the current status of the metal Additive Manufacturing industry and analyzes on how to derive a successful business strategy for suppliers as well as users of the technology.
The competition on the Additive Manufacturing supplier market is continuously growing. Feedstock suppliers, machine vendors, suppliers of auxiliary products and services as well as service bureaus strive for differentiation and a competitive advantage. To achieve the business goals a sound strategy is required. Basis for a strategy is the analysis of the current situation on the supplier market. An approach based on a business model canvas is described in this study to derive a specific business proposal and hence develop a business strategy. This includes the essentials of a unique value proposition as well as the development of a go-to-market strategy.
Every business faces the decision on choosing the right time to use a new technology. More and more enterprises begin to innovate their products and services with Additive Manufacturing that enables them to satisfy customer demands. Pioneers have the opportunity to shape the market, whereas late entrants have the luxury to base their decisions on a mature market. Ampower Insights provides an approach from understanding the customer benefit to decision making on using Additive Manufacturing.
The introduction of a new technology comes with changes that impact not only the shop floor but the whole organization. An analysis provides an insight on the importance of change management for implementation of Additive Manufacturing.
The use of Additive Manufacturing becomes successful, if products and services with added customer value are realized. A classification of four different fields is presented, where Additive Manufacturing enables such benefits. To identify potential applications, the bottom up and top down approaches are introduced.
Finally, the application has to be realized by the right technology. With a multitude and ever-growing number of metal Additive Manufacturing technologies, the options have to be analyzed and assessed. The presented technology map can help with a structured evaluation of the different Additive Manufacturing technologies.

Download this study at www.am-power.de/insights

Supplier strategy
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User strategy
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Content

About Ampower

Ampower is the leading consultancy in the field of industrial Additive Manufacturing. Ampower advises their clients on strategic decisions by developing and analyzing market scenarios as well as compiling technology studies. On operational level, Ampower supports the introduction of Additive Manufacturing through targeted training program as well as identification and development of components suitable for production. Further services include the setup of quality management and support in qualification of internal and external machine capacity. The company is based in Hamburg, Germany.

Introduction

Metal Additive Manufacturing business today

Compared to the global market of metal products, Additive Manufacturing is a niche business. Over the past decade, this niche, however, has been characterized with double digit growth rates and a consistent increase of market players.

So far the AM industry consisted mainly of specialized suppliers and industrial end users from small and medium sized enterprises active in different verticals. Over the past few years, an increasing number of large multi-national enterprises entered the market as AM users or to establish products and services along the AM supply chain. Overall, the AM market will stay highly dynamic and offers large potential due to the development of new working principles, further exploration of processes and advancements in software solutions.

Metal Additive Manufacturing market (ca. 0,2 %)

GLOBAL METAL MARKET

Business segments

The Additive Manufacturing market can be split into two segments, which will be evaluated separately: On one side providers of products and services in the AM supply chain and on the other side AM users across all verticals.

AM specific supply chain

Continuous innovations of solutions for the Additive Manufacturing process chain lead to an ever-evolving supply chain and enhanced competition. Small to medium sized enterprises dominated the AM market over the last decade. In recent years many large companies became active in the AM business and began to offer products and services to their existing customer base in the supply chain.

Feedstock suppliers

AM machine suppliers

Auxiliary products and services

Service bureaus

Vertical markets of AM users

Users across all verticals strive to create unique selling propositions and increase customer satisfaction by using Additive Manufacturing. Increase of product performance and reduction of manufacturing cost are the main drivers for metal Additive Manufacturing adoption today.

Automotive

Shipbuilding

Rail

Aerospace

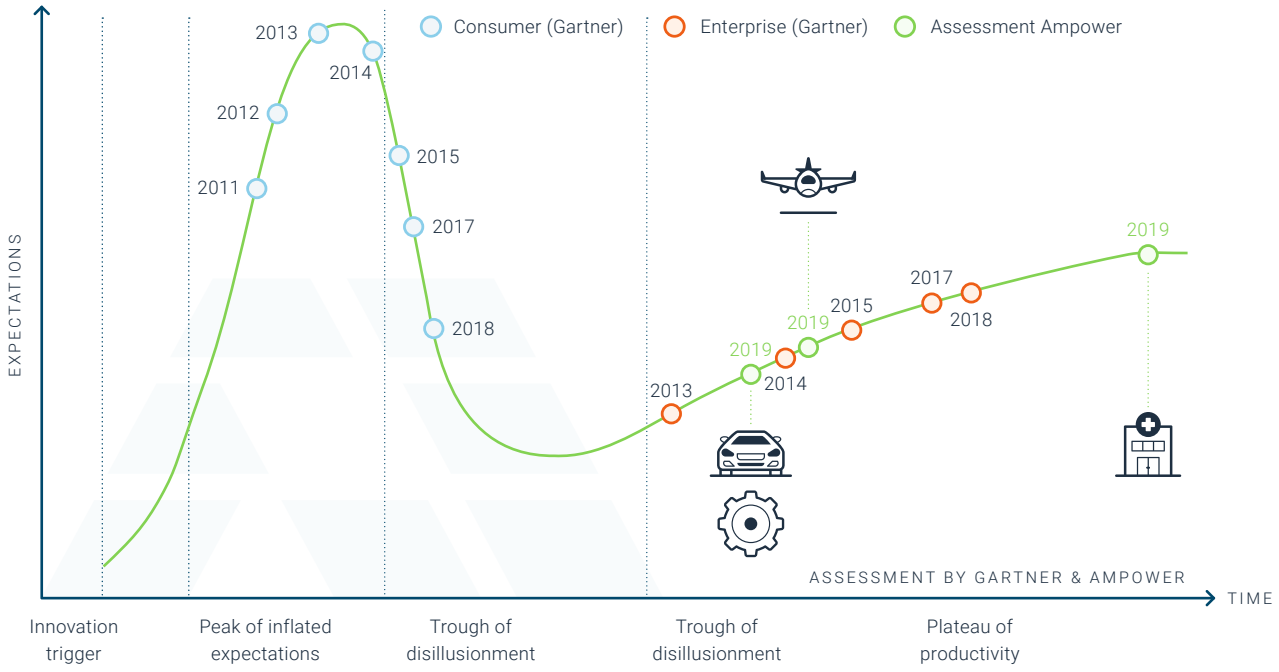
Medical

Machinery and tooling

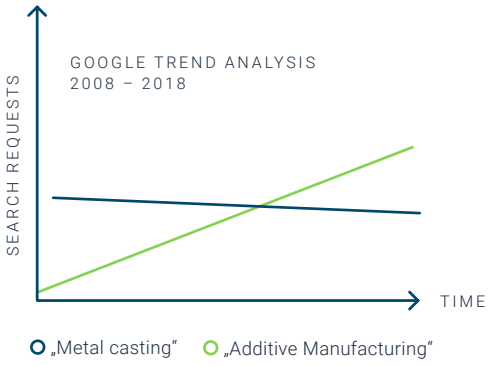
Additive Manufacturing scenario analysis

Evaluation of future developments within a market is the basis for decision making on market entry and strategy development. Scenario analysis is one technique to assess different market developments and to derive a business strategy based on the resulting predictions.

Scenarios can be evaluated from two perspectives, the AM user and the supplier. Users might ask themselves, if the trend towards individualization among their customers will continue to grow. This would support a decision to consider Additive Manufacturing as a possible technology. Suppliers might be interested in the growth potential and technology developments to decide on their market entry.

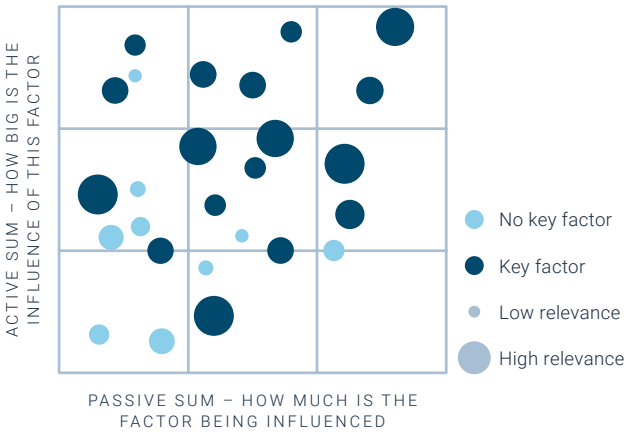


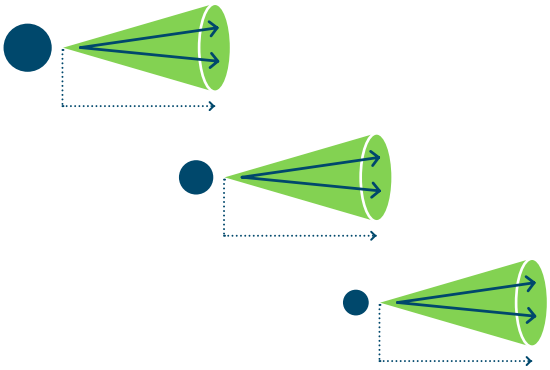
Trend analysis clearly indicates a continuous and significant growth of interest in Additive Manufacturing. This is visualized by a simple evaluation of Google trend search. 3D Printing related key words experience significant growth while traditional manufacturing key words either show a constant or slightly declining trend. This analysis is supported by professional assessments such as the Gartner hype cycle. The graph illustrates the consistent technology progress of industrial and enterprise 3D Printing. Additionally, the trend is supported by the current market push of new Additive Manufacturing technologies.



Scenario field analysis

The first step of a scenario analysis is the identification and assessment of influencing factors. Those factors are either technological or environmental. Technological factors for example are productivity of the processes. Environmental factors might be continuing trends towards customization.



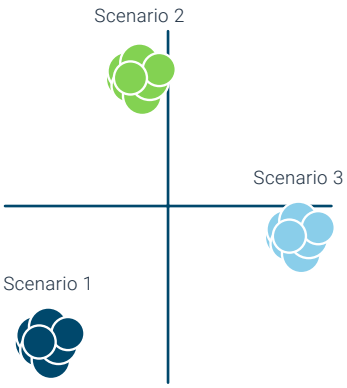


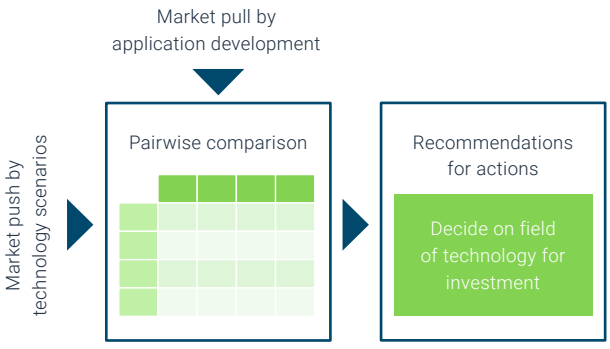
Projection

In the projection phase, future developments of each identified key factor are estimated. In terms of productivity, this can be described by a percentage value. Regarding trends for individualization, the projection can be increasing or decreasing.

Scenario clustering

In the third step, the projections are being compared regarding consistency. This leads to tendencies and clustering effects of certain developments, which can be described as scenarios.



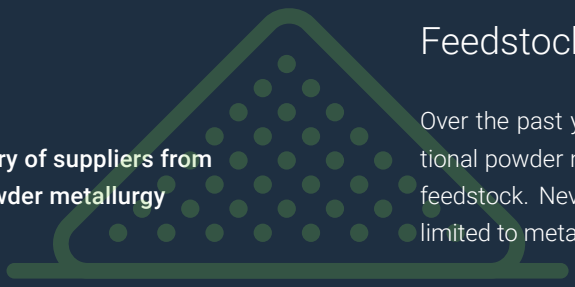


Scenario creation

The resulting technology scenarios are evaluated against the market pull application by application. A market can only gain substantial volume, if technology push and market pull are in balance.

Additive Manufacturing supplier strategy

Status quo of the Additive Manufacturing supply chain market



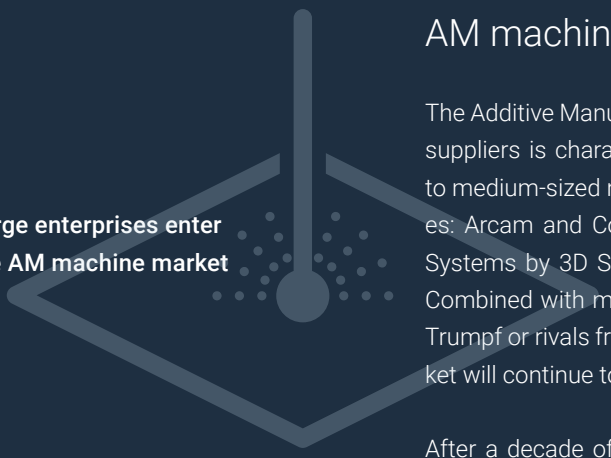
Feedstock supplier

Entry of suppliers from powder metallurgy

Over the past years, several companies with background in traditional powder metallurgy entered the market of metal AM powder feedstock. Nevertheless the current material range still remains limited to metal alloys well established in the AM industry.

Customers buy specified materials directly from supplier

The increasing knowledge base of customers regarding powder materials leads to general specifications and potentially standardized goods. Customers are shifting purchasing habits to avoid the costly machine supplier intermediary by directly buying from feedstock suppliers. The lack of differentiation between supplieres will increase competition and a potential race for cost leadership.



AM machine supplier

Large enterprises enter the AM machine market

The Additive Manufacturing market of powder bed fusion machine suppliers is characterized by years of consolidation. Many small to medium-sized machine OEMs were acquired by large enterprises: Arcam and Concept Laser by GE, MTT by Renishaw, Phenix Systems by 3D Systems, Realizer by DMG Mori, to name a few. Combined with market entries of other powerful players, such as Trumpf or rivals from South-East Asia, the powder bed fusion market will continue to experience strong competition.

Little differentiation in powder bed fusion technology

After a decade of significant innovations, today, the suppliers of powder bed fusion machines struggle to differentiate. The combination of hardware, software and services can create a competitive advantage. Trends to achieve cost or quality leadership can also be seen.

Continuous innovations in metal Additive Manufacturing

Innovations in other technologies, such as sinter-based processes, are about to be introduced to the market by well-known enterprises such as Hewlett-Packard or Stratasys and create even stronger competition.

Auxiliary products and services

Specialized post processing solutions

In metal Additive Manufacturing, the auxiliary products and services are a broad field. Suppliers offering post processing technology have recognized AM as an attractive market. Research and development activities were initiated several years ago and yield first results today. Traditional products or makeshift solutions are substituted by adapted or new machinery and services specializing on AM part and process characteristics. Furthermore, customers appreciate the added value gained from extensive AM experience in suppliers' application test centers. An AM specific branding may enhance recognition value.

Consumable and spare market will thrive

Growing demands for consumables and spare parts as well as additional services, previously only provided by machine OEMs, offer an opportunity for new market entrants.

Service bureau

Large suppliers closely monitor developments

The majority of AM service bureaus are all purpose small to medium-sized enterprises that offer a wide range of manufacturing services and materials. Large enterprises with roots in the traditional supply chain are closely monitoring the development to enter the market, if opportunity arises.

Success through specialization

Successful service bureaus today have strategically established a competitive advantage. They offer a highly specialized AM production with complementary services. The specialization can be an industry or application focus including necessary engineering services, meeting regulatory requirements or use of uncommon materials. The customers recognize the added value they receive and will choose suppliers that provide solutions to enable their specific application.

"More and more customers have increasing demands from the Additive Manufacturing supply chain. High quality products and services, a broad knowledge base and an agile organizational structure are beneficial to meet those demands."

MANUAL LAUX
Business Development Manager at Rösler

AM supplier market competition

A business strategy is employed to achieve mid to long term goals of a company. Understanding the market of the Additive Manufacturing supply chain in terms of competition is vital to align the strategy along an optimal path.

Low competition leads to high profitability in an attractive market and vice versa. Dating back 40 years now, Michael E. Porter published the approach of five forces to evaluate the competition in a market.

The analysis of competition in the AM supplier market is based on the model of Porter's five forces. The method may be used as starting point to create a structured overview of the competitive situation of any given company.

Feedstock suppliers

AM machine suppliers

Auxiliary products and services

Service bureaus

Bargaining power of **supplier**

- Customized or high performance materials inaccessible or high licensing fees.
- Unique or dominating products, such as components for laser scanning.
- Threat of increase of forward integration.
- Proprietary systems and technology not for sale.

Threat of **new entrants**

- Establishing of distribution channels to users that do not publicly disclose use of AM with the intention to keep competitive advantage in their vertical segment.
- Understanding market demands.
- Lock-in effect for customers due to reduced risk of switching proprietary processes.
- Intellectual property protected through obscuring cloud of patents.
- High level of knowledge required to develop products and services for broad variety of Additive Manufacturing users.

Competitive rivalry in AM supplier market

- High intensity of competition in certain market segments such as laser powder bed fusion due to numerous market players with similar products and services as well as low differentiation.
- Large multinational cooperations entered AM supply market with high commitment.

Bargaining power of **buyer**

- High knowledge on processes and materials.
- Low differentiation for certain products.
- Excess in capacity on supplier side.

Threat of **substitutes**

- Innovations in Additive Manufacturing technologies lead to threat of obsolescence of current technology.
- Extensive R&D led to high cost of products and services. Increased risk of switching to lower priced substitutes.
- High switching cost in regulated or highly demanding industries due to requirements of extensive qualification and certification.

The AM business model canvas

The business model canvas is a tool introduced by Alexander Osterwalde in 2008. It provides a structured overview of a business proposal and basic strategy decisions. At Ampower we adapted the canvas for the Additive Manufacturing supply chain.

The business model canvas structures the supplier strategy. All major elements for a successful AM strategy are covered by the canvas. The first step is to analyze the customers and identify their demands for products and services. This leads to the value proposition where the supplier describes the core product or service.

In a next step resources, activities and partners are structured on the left side of the canvas. The go-to-market strategy and sales strategy are described by the customer relationship and distribution channels. Finally, cost and revenue streams have to be analyzed.

"A major key activity is our global training program which enables our customers to be successful with Markforged Technology. Focusing on successful applications and customer segments is driving the growth of Markforged today."

JON REILLY
VP of Product at Markforged

KEY PARTNERS

Partnerships are important to develop and realize a go-to-market strategy. Partners can be other suppliers of different process steps, strategic beta customers and user groups or organized networks as well as norming associations.

KEY ACTIVITIES

Key activities are the development of a customer solution. In AM those activities should be focused on problem solving for the AM end user.

KEY RESOURCES

For the supply chain in Additive Manufacturing, a key resource is often a demonstration area or facility. Resources also refer to HR capacities. Since the AM industry is knowledge driven, qualified staff is most critical.

VALUE PROPOSITION

The value proposition describes the core product or service that the supplier is offering to customers. The value proposition is developed through the key activities and key resources.

- What value do we deliver to the customer?
- Which one of our customer's problems are we helping to solve?
- Which task are we helping the customer to get done?
- Which customer needs are we satisfying?
- What bundles of products and services are we offering to each customer segment?

CUSTOMER RELATIONSHIP

The AM world is driven by application specific knowledge and development. This results in a personal customer relationship based on a good business development and application engineering team.

CHANNELS

Sales channels are driven by personal contact and direct sales. Many system suppliers also use indirect local distribution partners. Online portals for part production are on the rise.

CUSTOMER SEGMENTS

The end users for Additive Manufacturing are found in all verticals. The technology is currently driven by

- Automotive
- Medical
- Tooling
- General Engineering
- Aviation

A clear focus on and knowledge of relevant customer segments and their applications is a key factor for a successful AM strategy.

COST STRUCTURE

The cost structure largely depends on the value proposition and the activities and resources that are invested. Since the Additive Manufacturing market is still a niche market with high growth rates and many new players along the supply chain, the investment rates are still comparatively large.

REVENUE STREAMS

Additive Manufacturing is a niche technology with high expected growth potential. Hence, only few suppliers are currently making substantial profits in Additive Manufacturing. The described revenue streams and cost strategy largely depend on the product or service. Pricing strategies are based on market values and the added value for the customer.

Developing a value proposition

Success in Additive Manufacturing is driven by market and technology knowledge. While large cooperations are entering the market with a holistic product portfolio along the whole process chain, SMEs are well advised to focus on specific USPs for their market entry.

Market research is essential for a successful product within the supply chain. A value proposition has to be based on the customer needs. In a non-disruptive approach, the value proposition is part of an existing supply chain and improves specific aspects. However, the current situation on the AM market is driven by disruptive approaches. Almost weekly, new AM technologies as well as new developments in materials and post processing become public.

The identification of new products and services is a balance between the capabilities and resources of the supplier and the need of the customer for disruptive solutions. Lately, the sheer number of new solutions makes it difficult for the users to choose and adapt the optimal technology for their applications and processes. Customer readiness has to be taken into account when approaching the market with disruptive value propositions.

Non-disruptive approach

A value proposition, which is adapting to the current market and technology process chain but improving certain aspects.

vs.

Disruptive approach

A value proposition, which is introducing new technology principles and process as well as business models (e.g. Vader, 3yourmind, …)

"The Additive Manufacturing supply chain is driven by quality and knowledge. The successful products and services on the supply chain market all have deep process know-how and customer application knowledge in common."

PHILIPP SPERLING
Sales Laboratories and R&D at YXLON

Customer application
Which applications are end users producing with Additive Manufacturing?

Pains
Which problems are end users facing along the AM process chain?

Gains
What will help customers to be more successful in Additive Manufacturing?

Gain creators
Which advantage can the supplier offer to the AM user?

Pain relievers
How can the supplier solve the problems of the AM user?

Products & services
Which products and services can the supplier offer to the AM user?

Marketing and sales

Global technology

An unbiased decision process should be basis for purchasing a production technology. Performance, reliability and cost are main drivers and of interest to the customers.

Marketing to vertical segments such as medical, aviation or automotive often require specific wording and are thus addressed by separate campaigns.

Distribution channels

Companies already active in other fields than Additive Manufacturing benefit from traditional sales channels to potential customers. Their sales team can offer Additive Manufacturing equipment and services as additional items and thus increase the chance to conclude a sale. While some major players in polymers use channel distributers, marketing and sales activities of metal AM machines are in close coordination with headquarters.

Young user base

The user base in Additive Manufacturing is relatively young compared to other traditional production technologies. Additive Manufacturing technology is usually implemented in production environments without prior knowledge among the staff. Since no prior experience is available, tasks are assigned to young personnel.

The digital process chain calls for technology savvy personalities, which also addresses young engineers. The marketing and distribution channels should take this into account. Online advertisement, social media and content marketing should be of stronger focus than traditional channels. Online collaboration tools may be of higher interest for this user group.

„Process chains of metal Additive Manufacturing are highly complex and the resulting parts need to meet stringent design requirements. A strong relationship between customer and supplier is essential to successfully develop lean and robust processes that repeatedly deliver quality parts."

JIM SHIPLEY
Global Business Development Manager
at Quintus Technologies

Development of go-to-market strategy

Being successful as a supplier for Additive Manufacturing technologies or services means first of all to understand the user and his applications. The goal of a go-to-market strategy must be the creation of awareness and subsequently leads and sales revenue.

1

Target markets and applications

Who will profit from my service or product? This question should be answered when developing the value proposition. For the go-to-market strategy, the verticals and applications have to be clearly described.

2

Buyer and stakeholder

Technological solutions are sold to engineers. But usually sales procedures involve several other stakeholders that have to be addressed. Such stakeholders can be representatives from management, procurement, quality management or engineering.

3

Marketing channels

Buyers and stakeholders have to be aware of the solution and the company offering it. Hence the marketing efforts have to go through the channels that reach the identified stakeholders. Possible channels are fairs and exhibitions, conferences, scientific and popular papers and social media.

4

Marketing content

Today, marketing in Additive Manufacturing is content driven. Inbound marketing requires the right content to attract attention and create awareness.

5

Partnering and cooperation

While strategic customers are a good approach to understand the market and create awareness, partnerships with other suppliers along the value chain can create shared sales opportunities and increase marketing force.

6

Distribution model

Additive Manufacturing technology still needs a close customer relationship and involvement of application engineers and market developers. However, for market expansion and wide regional coverage, indirect sales by representatives and resellers is an option to consider.

Additive Manufacturing user strategy

End user's strategy: right time of market entry

The commitment to an Additive Manufacturing technology as well as the time of market entry marks a significant decision.

Over the past 20 years, metal Additive Manufacturing has been introduced successfully into many industries. First movers utilized their competitive advantage and placed products and services to secure a strategic market position. However, to enter as first mover may not always be the best choice.

Advantages as well as disadvantages come into play for first movers and followers alike and have to be assessed accordingly. With continuous improvement of machines and processes as well as inventions of new working principles, followers may gain the upper hand by adopting superior technology.

First mover

Advantages

+ Competitive advantage with innovative products
+ Securing intellectual property
+ Occupation of niches
+ Reputation on the market
+ Partnerships

Disadvantages

– Extensive R&D effort to develop processes and services
– Reliability and availability of technology
– Risk of commitment to inferior technology
– Lack of standards and qualification knowledge

Follower

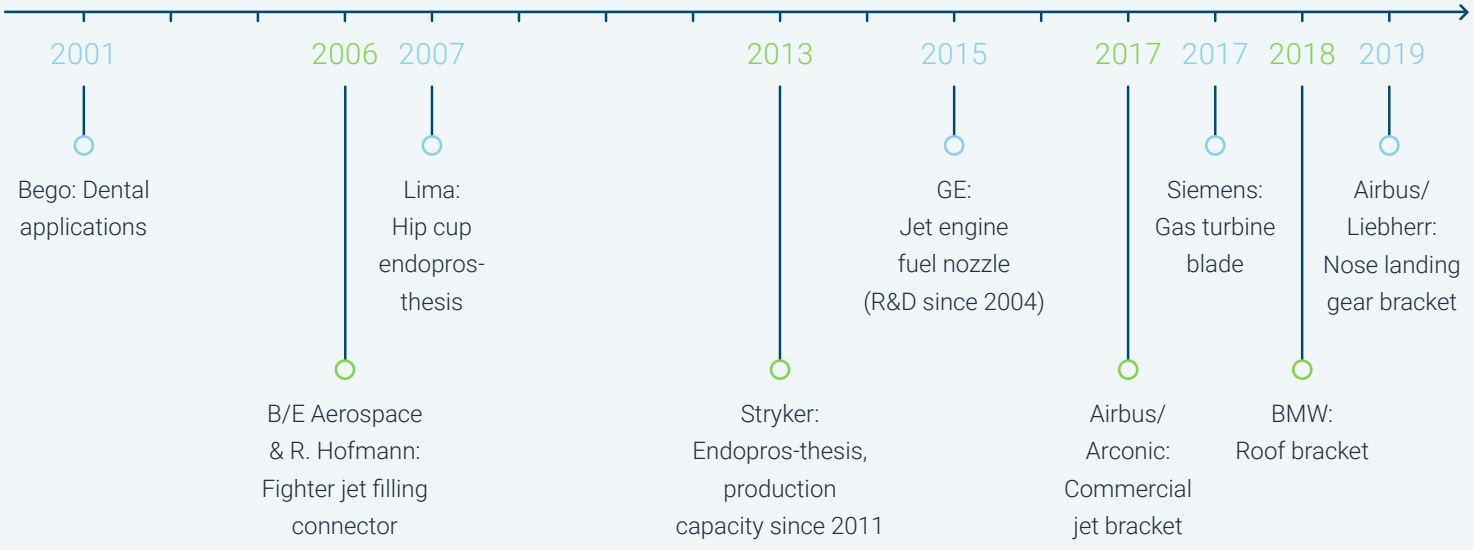
Advantages

+ Benefit from developed processes and supply chain
+ Cherry picking and avoiding of pitfalls
+ Chance to employ next generation of technology
+ Shortcut through acquisition of knowledge
+ Educated customers
+ Use of established standards and best practices

Disadvantages

– Risk of substitution of products
– Risk of (permanent) loss of market share

OVERVIEW WITH SELECTED EXAMPLES



Road to metal AM series applications

The road to series production of metal Additive Manufacturing products is long. In the 2000s, announcements for serial applications were mainly found in medical and aviation industry. They identified applications with high benefits from adapting AM specific characteristics. Other industries such as tooling were also successful in utilizing the technology.

Some industries, such as automotive still struggle with today's high price for metal applications. Only recently the ramp-up of a first automotive series part was announced.

Often advancement in highly competitive industries is not made public but is well guarded intellectual property of the respective owner. The use of metal AM production tools, for example, are not marketed by users, however, they provide significant cost-saving potential and performance increase.

Overall the frequency of press releases on success stories of metal AM series applications has significantly increased over the past years. Especially in medical and aviation, best practices and increased knowledge among users and authorities alike facilitate introduction of innovative metal AM products in series.

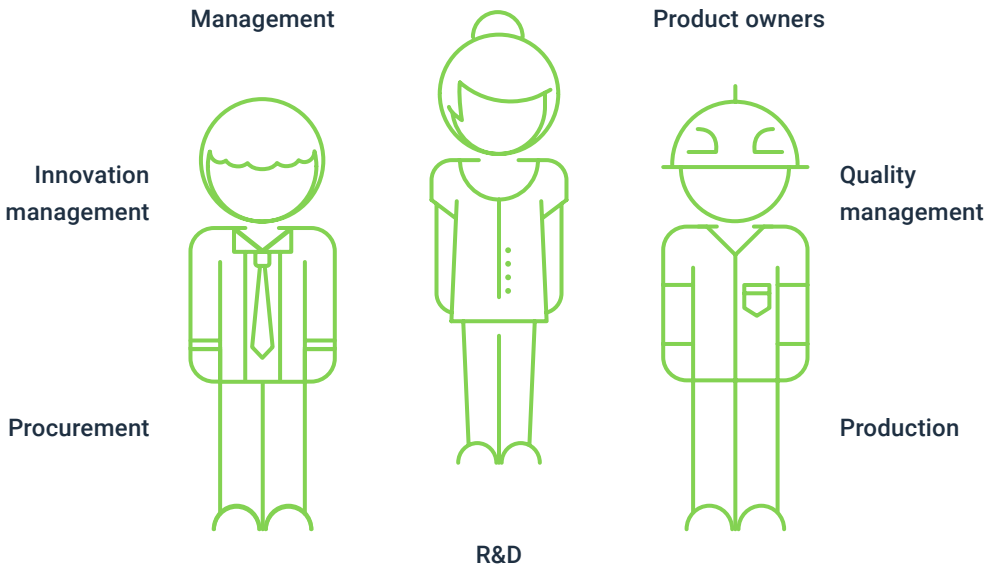
Developing the right technology strategy

When formulating a business strategy, the central question should be: How do I satisfy the customer's demands? To add further value to products and services, innovative technology such as Additive Manufacturing can be an answer.

Customer satisfaction should be of highest importance for a profitable business. In a competitive market, products and services therefore require an added or possibly unique value. Innovative technology can lead to this competitive edge. However, Additive Manufacturing is certainly not the holy grail providing solutions to everything. An unbiased analysis among all viable production technologies is vital to choose the best route. The application needs to choose the right technology, not technology its applications. This requires an extensive knowledge base of viable manufacturing technologies, their advantages, but also limits as well as information about factors of cost and time.

Formulating and especially executing a strategy to utilize Additive Manufacturing is a highly challenging task. Examples from industry show a time frame of multiple years from first opportunity identification to eventual ramp-up of production. The introduction of a new technology has high impact on almost all areas of an organization. An interdisciplinary core team to execute the project is advisable.

Strategy and execution: Interdisciplinary task



From potential to implementation

How do I satisfy the customers' demands?

Identify opportunity in products and services with potential for added value

What is the right technology to bring these products and services to market?

Identify suitable technologies by market screening – Additive Manufacturing may be a viable solution

What processes and supply chain is required?

Pilot study and knowledge transfer

Will this result in a profitable business?

Detailed market and scenario analysis

Decision to use Additive Manufacturing

Implementation and qualification of Additive Manufacturing supply chain

„Adoption of new technologies is critical to achieve a competitive advantage in medical industry. For certain products, Additive Manufacturing can significantly improve product performance while reducing manufacturing cost."

HELMUT D. LINK
Managing Director at Waldemar Link

The importance of change management for AM implementation

The implementation process of Additive Manufacturing technology is facing typical challenges when changing internal processes. A structured and transparent AM strategy can help avoid obstacles along the way.

1 **Change of technology**
This describes the usage of AM instead of an alternative manufacturing technology.

2 **Change of design**
Often, Additive Manufacturing potential can only be utilized, if the design of the part but also surrounding environment is considered.

3 **Change of material**
With Additive Manufacturing different materials have to be introduced or hybrid material designs are possible.

4 **Change of performance**
Different material properties, topology optimized design or integrated designs of AM parts have an influence on dimensioning and surrounding parts.

5 **Change of assembly and workflow**
Due to integral designs, Additive Manufacturing can change or reduce the assembly process and make tooling unnecessary.

6 **Change of business model**
Disruptive AM services and technologies enable new business models.

7 **Change of supply chain**
The implementation of AM can have an influence on the supply chain by bringing back external manufacturing capacities to an internal AM production.

8 **Change of data generation**
AM enables individual or customized components which results generating individual data and designs.

9 **Change of sales and marketing**
By introducing shorter lead times and customizable parts, Additive Manufacturing can have a large impact on the marketing and sales processes.

Change impact assessment

Every step leads to an increase of potential of added value for the company by its implementation. However, changes also imply possible threats to existing structures. The employees have to be included into the change processes. Only if they see the added value for their position and their range of duty, they will support the implementation strategy. The number and amount of changes has to be carefully chosen. Sometimes it is best to start the implementation of Additive Manufacturing with an application with little changes but many observable advantages. A good example are manufacturing aids.

Added value for customers

The opportunities for added value by Additive Manufacturing are versatile. The target for a sustainable AM strategy should focus on adding value for the end customer.

While searching for Additive Manufacturing applications, users should first of all ask themselves, where Additive Manufacturing can add value to their product or service. In most cases, manufacturing additively is more expensive at first glance. A business case evolves, when the new component can save money or increase the value of the product in general. Those business cases can be clustered in the four "fields of added value by Additive Manufacturing". The first segment is the oldest group of application and represents advantages by prototyping and support of research and design.

The second segment often offers fast advantages for the user by using Additive Manufacturing for tools and manufacturing aids. Here the cost of traditional manufacturing is high due to the low quantities and high complexity. The third field proves to be more complex since end products and performance are improved. Those business cases always require extensive expertise in re-design and qualification. The fourth and last field is related to improvement of services and aftermarket. Manufacturing of spare parts and obsolescence parts are typical use cases.

"The freedom of design by Additive Manufacturing enables Airbus to increase performance while reducing weight cost of components. Once the technology will be fully utilized, our customers will profit from those advantages directly."

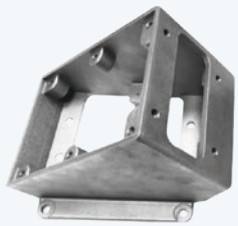
JENS TELGKAMP
Head of Additive Manufacturing R&T
at Airbus

Re-design vs. new design

For most companies, the first step of AM implementation is the substitution of existing components or assemblies. This leads to fast success stories and limited change management efforts. However, the full potential of Additive Manufacturing can often only be tapped when considering Additive Manufacturing from the beginning of the design process of a system.

Fields of added value by Additive Manufacturing

Example:
Spare parts



Terminal box for
20 year old train

Example:
Prototyping

Automotive cylinder
crankcase prototype

Example:
Valve block

Optimized aerospace hydraulic manifold

Example:
Manufacturing tools

Hydraulic actuator housing tool

SOURCES: FIG 1 DEUTSCHE BAHN I FIG 2 ROBERT HOFMANN GMBH I FIG 3 LIEBHERR AEROSPACE I FIG 4 MARKFORGED

Top down vs. Bottom up

Two approaches are known for identifying potential parts for Additive Manufacturing. The bottom up method leads to a wider range of applications and higher potentials. The top down method may yield fast results assuming reliable data is available and meaningful search criteria can be identified and combined.

Top Down

1. Definition of search criteria

2. Collection of relevant part data

3. Data search and part identification

4. Part evaluation by AM department

5. Prototype or first series

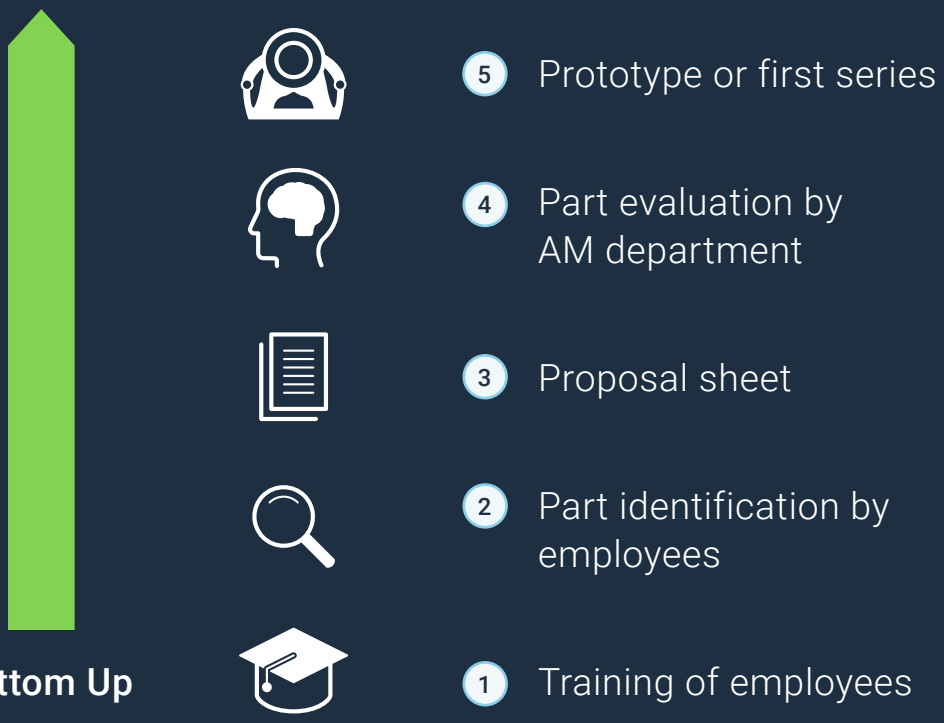
Advantages

+ Fast screening of large amounts of parts
+ Objective assessment

Disadvantages

– Difficult collection of relevant data
  - Varying sources (SAP, CAD, drawing)
  - Different formats (digital, analog)
– Extremely large amount of information
– Search combinations necessary
– Software or search tool necessary
– Employees are not involved, possible resentment

Top down vs. Bottom up



Advantages

+ Involvement of employees reduces change risks
+ Problems are solved which increases acceptance
+ Identification of relevant parts from field experience
+ Easy collection of relevant data
+ Including more fields of potential such as design integration and new business models
+ Implements sustainable knowledge company wide

Disadvantages

– Time-consuming training of employees
– Possibly subjective assessment
– Screening limited to smaller amounts of parts

The right technology for identified applications

The application should drive the choice of technology. A wide range of new Additive Manufacturing technologies emerged and will lead to more design and purpose driven products.

The basic principle of "application drives technology" has limits due to limited technology knowledge in R&D as well as design departments. This leads to a corporate strategy of which technologies will be used for manufacturing within a company. When implementing Additive Manufacturing into this corporate technology strategy, the choice of the AM technology is critical. Today more than 15 different metal technologies are available. To identify the technology focus for R&D departments, a benchmark of potential applications has to be conducted. Ampower introduces a four step process to identify the right technologies for the company to focus on.

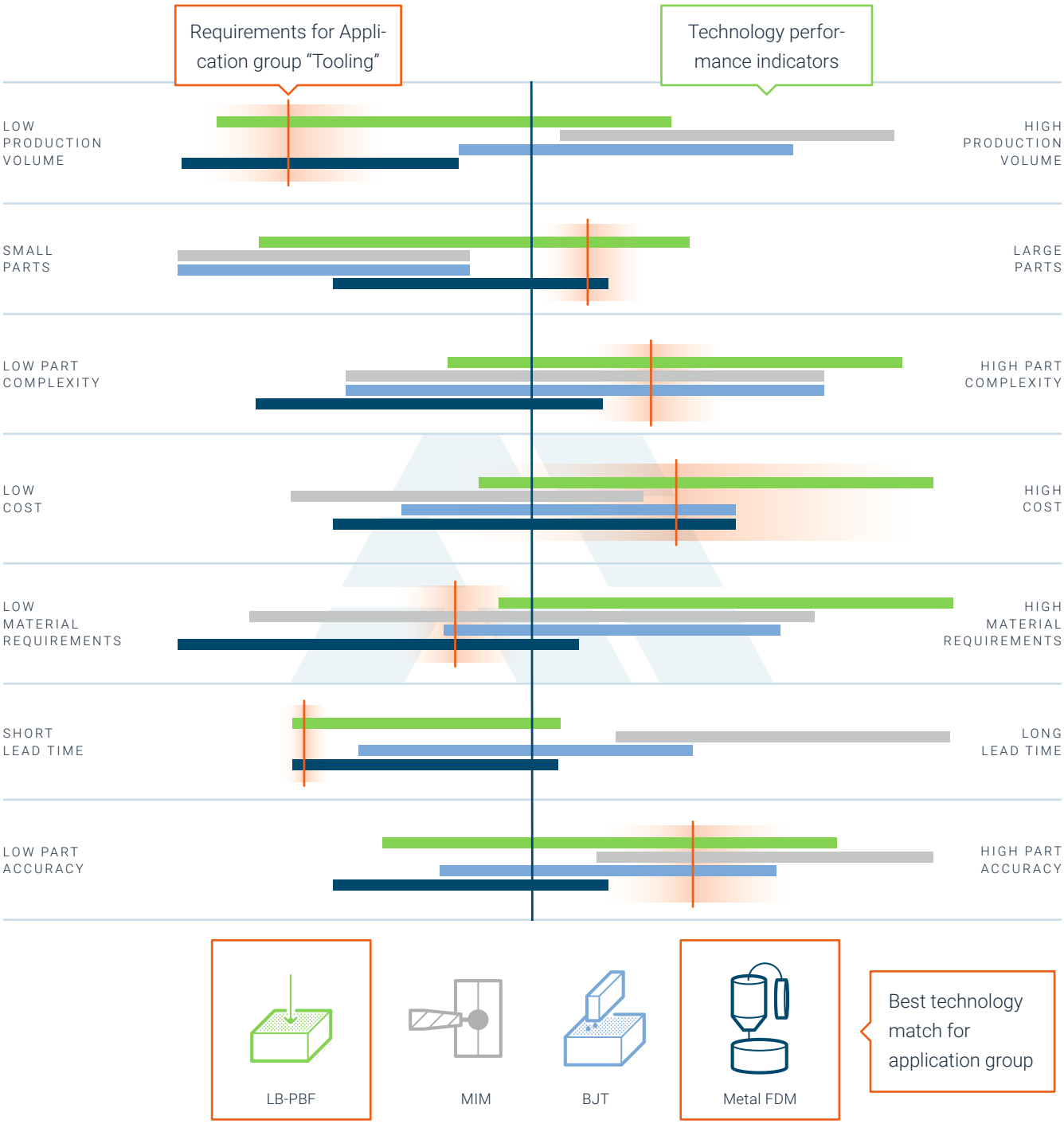
1 **Step 1: Application groups**
The potential applications have to be grouped in tooling, prototypes, spare parts and final parts.

2 **Step 2: Requirements**
For each application group, technical key requirements have to be identified and defined. This includes for example material properties, surface quality and dimensional accuracy as well as overall part size, but also quantities and lead time.

3 **Step 3: Technology performance map**
The complete range of technologies including current AM technologies has to be defined. The performance of those technologies are determined and analyzed as state of the art and with a 5 year forecast.

4 **Step 4: Technology match**
Requirements from step 2 and the technology map of step 3 have to be matched to reveal the best suited technologies. Usually no ideal match is to be expected. Deviations should be documented and analyzed towards possible solutions and fields of research.

Examplary technology match map



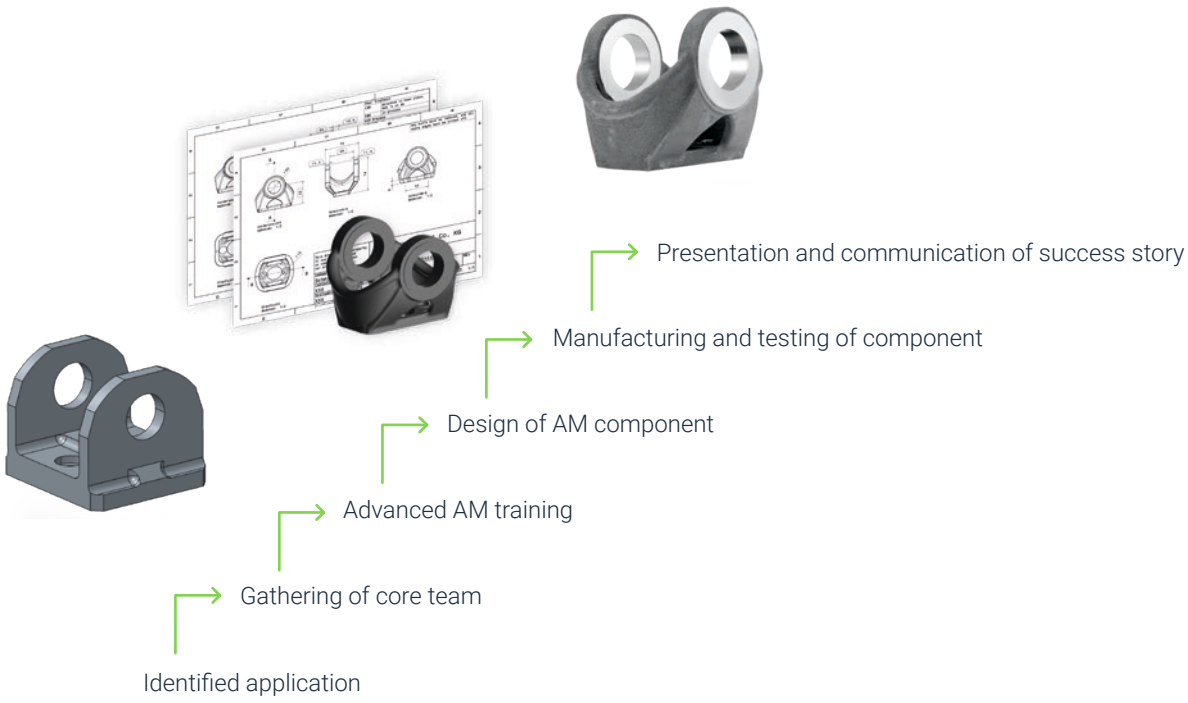
Access a complete technology performance map!

The Ampower Metal AM Report will be released in November 2019. The report will contain a complete and comprehensive technology performance map to help you focus on the right metal AM technologies. The map will cover multiple metal AM technologies and more than 15 different performance indicators.

Know-how transfer and pilot project

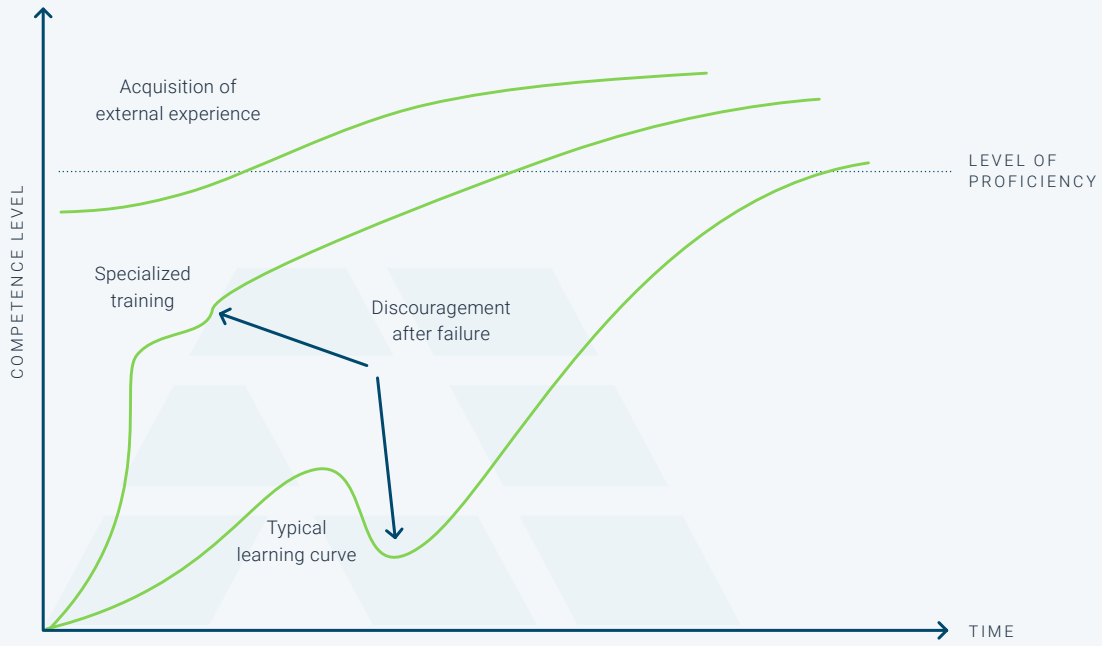
An AM core team and a pilot project are the best start to build knowledge, create awareness as well as confidence and to set the basis for a successful implementation roadmap.

A pilot project describes a first Additive Manufacturing application within the company. Ideally an application is chosen with minor impact of change on processes, while at the same time solves current issues of the engineering team. Good examples for pilot projects are prototypes or manufacturing aids, since their impact on the organization is minor, but the benefits can be high. The pilot project is also an ideal way to build knowledge in a core team and growing a network of partners along the supply chain.



Management support and adequate financial funding are critical for a successful pilot project. Typically, the time span of such a project is 6 months. Personnel efforts are around one full time equivalent. The budget is about 50.000 € for external services such as training and manufacturing.

Asking established AM users what is key to their success, knowledge is named as most prominent. The design of products, development of processes and their execution have large impact. With rapidly changing environments, new technologies and processes, continuing education is needed to adapt to the ever-evolving status quo.



Additive Manufacturing with regard to all its different types, materials and applications is a fairly complex technology. According to interviewed players on the market knowledge is the key to success.

AM has its unique digital workflow and automated building process. Therefore, the design of products, development of processes and their execution have large impact from each invidividual involved.

With rapidly changing environments, new technologies and processes, continuing education is needed to adapt to the ever changing status quo.

About the authors

Dr.-Ing. Maximilian Munsch

Since 2007, Maximilian Munsch is a professional user of Additive Manufacturing. After finishing his dissertation on reduction of residual stresses in metal Additive Manufacturing in 2012, he acquired extensive hands-on experience with metal powder bed based Laser and Electron Beam Melting processes in industry. His focus is on the full Additive Manufacturing process chain required for industrial production. Max has successfully planned, implemented and qualified multiple Additive Manufacturing productions for regulated applications.

Matthias Schmidt-Lehr

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 is committed to customer satisfaction, project management and controlling. In his former positions Matthias gathered experience in business development, customer relationship management, as well as marketing and sales.

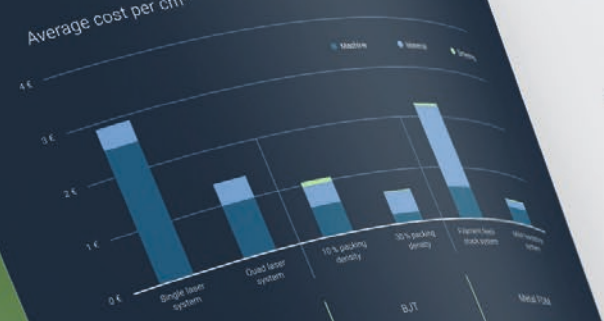
Dr.-Ing. Eric Wycisk

Eric Wycisk can look back on 10 years in Additive Manufacturing with a focus on metal, especially titanium alloys. In his former affiliation, he was team leader and Key Account Manager for aviation applications and light weight design. He managed multiple projects concerning topology optimization and light weight design, process development and optimization as well as industrial implementation of Additive Manufacturing. The research in Eric's dissertation focuses on fatigue properties of laser beam melted Ti-6Al-4V.

Cost as the game changer

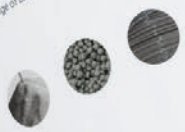
Compared to traditional high-volume manufacturing technologies, LB-PBF is generally associated with high machine and material cost at low production speed. Thus, not every part that is technologically feasible is reasonable from a business perspective. Sinter-based metal AM technologies promise to change this and lower the cost for metal parts for higher production volumes.

Average cost per cm³



Material

The cost for stainless steel powder suitable for LB-PBF ranges between 40 to 80 €/kg. Similar to conventional powder particles. However, BJT start-ups like Desktop Metal claim to work with classical MIM powder. This could tap into significant material cost saving of up to 90 %. MIM powder of alloy 316L has a price range of only 6 to 12 €/kg. For metal FDM, the feedstock consists of wire, granulate or rods made of metal powder and polymer binder compound with significant spread in feedstock cost. While granulates are based on classic MIM granulate and range between 16-18 €/kg for alloy 316L, filaments such as the BASF Ultrafuse 316LX are priced at 200 €/kg. However, similar metal filaments from alternative suppliers are available for 100 €/kg.



Productivity

Analysis shows, that LB-PBF production speed mainly depends on the number of lasers working parallel in the build chamber. For metal FDM the layer thickness is the key factor to increase the build volume per time. By increasing this parameter, the production rate increases but also leads to a strong reduction of resolution and surface quality. As mentioned above, the cost for feedstock also vary depending on the system. Production speed in binder jetting is calculated from the total build job time and the packing density. The packing density reflects the sum of all part volumes referred to the complete build envelope. Packing density is typically 10 % for mixed build jobs with different parts and 30 % for optimized stackable parts in a large volume production. Build job times are between 20-40 hours. Considering advertised improvements of the technology within the next years the build envelope will increase while the total build job time reduces to 10 hours due to single pass jetting.

Missed out on our previous Issues?

Vol. 1: Additive Manufacturing – Make or Buy

Additive Manufacturing became a game changer in many industries. Especially for SMEs, however, high part costs are still the main restriction for further wide-spread adoption of this production technology. Ampower Insights Vol. 1 gives a detailed calculation of production costs and introduces the ratio of cost per unit of volume for an easy comparison of technologies and materials.

Vol. 2: Additive Manufacturing of Automotive Components

Medical and Aerospace companies count among the early adaptors of metal Additive Manufacturing. The usually highly innovative automotive industry, however, so far struggles with the high manufacturing cost of Additive Manufacturing. An exception are high performance cars with low production volumes and demand for customization. In the second issue Ampower Insights provides a deep dive into the manufacturing route of high performance automotive components.

Vol. 3: Metal Additive Manufacturing with sinter-based technologies

In this study, Ampower presents an objective and independent view on the current capabilities of sinter-based AM technologies compared with LB-PBF and metal injection molding (MIM). By analyzing over 50 specimens from 9 different system suppliers, Ampower is revealing the characteristics of the different technologies.

Vol. 4: Quality in Additive Manufacturing

Additive Manufacturing is entering industrial serial production. Especially in regulated industries such as aviation and medical, the need for internationally accepted standards and proven practices for machine qualification is continuously growing. To meet this demand, Ampower Insights Vol. 4 presents a comprehensive approach and best practices to establish a qualified production environment and gives an overview on standardization efforts and published standards.

Download **Ampower Insights Vol. 1 – 4**
at www.am-power.de/insights

AMPOWER

Ampower GmbH & Co. KG
ZAL TechCenter
Hein-Saß-Weg 22
21129 Hamburg
Germany

+49 (0) 40 99999 578
info@am-power.de

www.am-power.de