Impact and Influence Factors of Additive Manufacturing on Product Lifecycle Costs

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Accepted August 16th 2013

Abstract

At first sight the direct costs of Additive Manufacturing (AM) seem too high in comparison to traditional manufacturing. Considering the whole lifecycle costs of parts changes the point of view. Due to the modification of the new production process and new supply chains during a parts lifecycle, producing companies can strongly benefit from AM. Therefore, a costing model for assessing lifecycle costs with regard to specific applications and branches has been developed. The costing model represents the advantages of AM monetary. For the evaluation of this model and the influence factors, different case studies have been performed including different approaches in part redesign. Deeper research is and will be carried out with respect to the AM building rates and the comparability of various AM machines, as these facts are hardly comparable for end users. This paper will present the methodology as well as the results of the case studies conducted over the whole product lifecycle.

Introduction

One of the critical success factors for the additive manufacturing technologies can be seen as the costs for the manufacturing process compared to traditional manufacturing [EKW+12]. Especially those potential users / customers that are not used to the technology cannot oversee the costing structure of Additive Manufacturing (AM). To understand this structure, costs of the whole lifecycle of parts need to be considered. For this reason the project CoA²MPLy "Costing Analysis for Additive Manufacturing during Product Lifecycle" aims to understand and rate the cost drivers of the whole product lifecycle. Focusing on Metal Additive Manufacturing (MAM), this shall expand the fields of application for AM parts. The result will be an easily manageable framework that can be used by OEM's, part suppliers and AM users [LJK12]. For this purpose, business processes have been modeled starting with powder production and ending with part recycling. A costing model for MAM has been developed to compare the costs of traditionally manufactured parts during different phases with the costs occurring within AM processes. To have the knowledge about these processes shall help the designers to get a deeper understanding of their actions and how to influence part redesign.

Nowadays many companies are not familiar with AM. Through the strong appearance in the media the topic got more important in the last years. Many companies think about AM as one possibility to increase their innovation potential. Unfortunately the knowledge about the capabilities and especially the limitations of the technology are widely unknown. They need to understand the economic influence factors of the technology to be able to select appropriate promising part candidates for a successful application of the AM technology in their company. Most costing models published in literature are strongly focused on the pure production costs and do not show the overall benefits of the technology. Therefore, this work describes an approach to define lifecycle costs analysis for AM. The overall aim of this work is to help end users with the part selection and to be able to utilize AM in an economic successful manner as a long term production alternative in their companies.

Methodology for assessing lifecycle costs

The methodology for estimating lifecycle costs in one part in a methodology for selecting appropriate parts for application in companies who consider using AM for their products. As the major aim of a company is to make profit, the costs of a product are still one of the most important factors for the decision making. Therefore, the costs of AM production need to be widely understood. As AM creates benefits along the production, the whole product lifecycle needs to be considered for properly assessing lifecycle costs.

When talking about product lifecycle many different definitions occur. In this paper the definition of the "intrinsic product lifecycle" will be used. Compared to other definitions it considers the lifetime of a product from the first idea until the final disposal of the part, while others define the product lifecycle as the time a product remains on the market [PaBe07]. During the product lifetime a product causes costs. These costs occur at the side of the manufacturer as well as on the side of the customer. While in the literature most people only discuss about purchasing and production costs, a deeper understanding for the costing structures need to be developed as AM has a deep impact on many aspects of the production chain. The work performed picks up the results of [LJM+12]. Based on last year's results the lifecycle costing (LCC) aspects have been added and the model has been refined during usage.

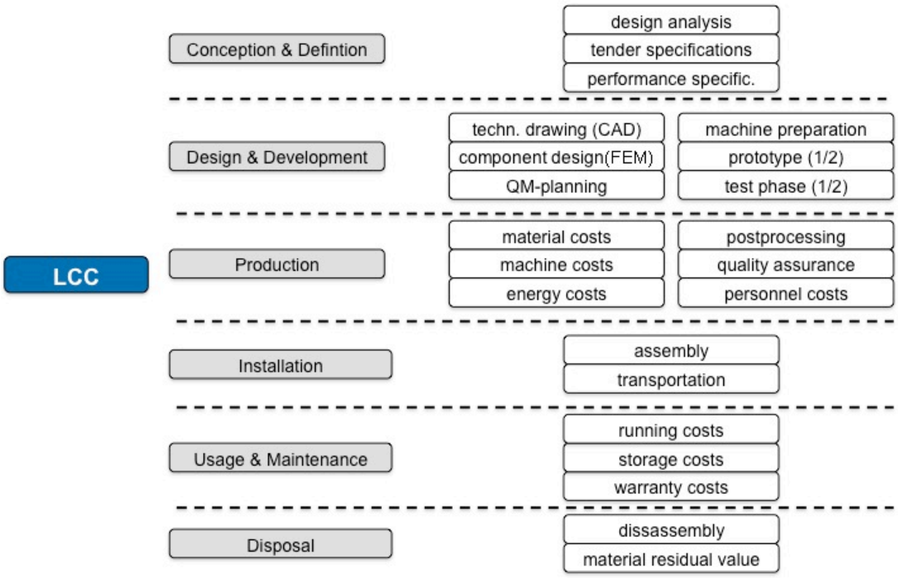


Figure 1: Different phases of the lifecycle costing model

The developed additional LCC model is based on the German DIN 60300-3-3 standard "Dependability management - Part 3-3: Application guide - Life cycle costing". Here, the mentioned calculation methods have been adapted to suit the comparison between traditionally manufactured parts and additively manufactured parts. The model consists of six major phases which are displayed in figure 1.

The model starts like most product development processes with a concept and definition phase. The major cost structure is set up by the costs for requirements definition as well as the design analysis.

This phase is followed by the design and development phase. The considered costs include technical drawings, the component design, QM planning, a prototype and test phase as well as the production planning. This phase will be capable of evaluating different aspects of the product design phase.

The costs of the production phase will by calculated by a model which is based on the work of Augsburg, Hopkins/Dickens (HD), Ruffo/Tuck/Hague (RTH) and Gibson/Rosen/Stucker (GRS). As a calculation method a “Time driven Activity Based Costing” (TD-ABC) approach has been taken. This approach allows the consideration of different influence factors on the basis the use of resources [CFG07]. For the estimation of cost relevant processes, the process steps of the initial model have been simplified into four main processes:

- Preparation of the building job
- Production of the building job
- Manual removing of sample parts and support
- Post processing to enhance material properties

These costs contain the aspects of material and machine costs considering the material-machine-combination as well as personnel costs, energy and consumption materials, post processing and quality control. The aspects of the different complexities of the building jobs can be taken into account through the use of different complexity factors. So far, this model is only applicable for the SLM production of metals (Ti6Al4,Al and 316L) but will be enhanced in the future regarding further metals and plastics. One of the major challenges is the calculation of the building time as the influence of the building speed has shown to be one of the most important manufacturing factors [LJM+12].

Equally some basic calculations for milling and casting operations have been included in the model to allow a basic comparison between several production possibilities. In consequence all phases need to be adapted as well to achieve comparable LCC results.
The next phase is the installation phase. This phase contains the costs for the transport and the installation of the product. Here the influence of the possible influence of the use of monolithic structures through intelligent AM use can be shown.

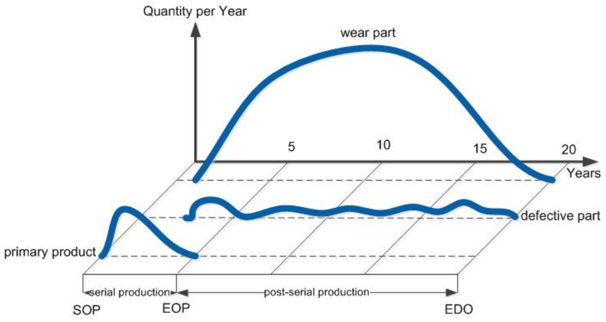


Figure 2: Displaying the product demand during part lifetime Source: [DoSC07]

Following, the phase with the costs for usage and maintenance includes the costs for the maintenance necessary logistics support and the usage of the part. The usage-based costs in this model are dependent on the weight of a sample part and therefore follow one simple rule. Increase in weight equals an increase in the usage costs. Thus, this model is not necessarily fully applicable for all branches. The additional usage of AM for other branches can still be evaluated if the costs for usage are considered as zero. The logistic costs include costs for storage of spare parts and others. To make it more applicable for the aerospace industry, a methodology for assessing carbon efficiency through weight savings has been implemented. Carbon efficiency costs of the logistics chain are not included.

The last phase is the disposal phase. The disassembly costs as well as the residual value of the material or alternatively the disposal costs summarize the costs in this phase.
As mentioned earlier the model can in general be used for several production processes. But adaption in all phases is needed and in some phases expert knowledge is necessary to gain exact results. The model needs to be adapted rigorously for different branches and application fields. Currently it strongly focuses on estimating lifecycle costs of AM-manufactured parts

for the aerospace industry. The adaption shall be facilitated in the future by the use of pre-defined application scenarios for certain branches and applications with specific scenario profiles as a guideline and as a starting point.

Development of application scenario - Efficiency

Performing a valid LCC analysis requires a deep knowledge of the different branches to which you need to adapt the existing models as many important factors vary. This starts with the different costing parameters in the companies and ends with the usage-based patterns of the product. If you compare the production targets of the automobile industry for instance in a formula student racing team and of an aerospace application you can easily understand that different factors are more important than others. Furthermore, the total production targets differ in a major way. Therefore, it is necessary to develop different application scenarios in order to gather correct data for the LCC model. Once this has happened for a certain product or a certain industry, the developed LCC model can easily be transformed to other application scenarios. In the following paragraph an application scenario for the aerospace industry is described.

In the aerospace scenario the civil aviation shall be considered. Here you can firstly divide the planes in five categories with different influencing factors. This differentiation starts with small airplanes with up to five tons and ends with long distance planes with up to 600 seats [HPP10]. Differentiations made in this sector regard e.g. the number of starts, landings and the total time of flight. The optimized part shall represent a part of the landing gear. The landing gear systems have a significant impact on the total weight of a plane and therefore as well on the energy consumption [SCK04]. The single-aisle aircrafts like the Boeing 757 with around 250 seats are the fastest growing group of these five candidates. Therefore, this plane will be the basis of the further discussions. Between 1982 and 2004 approximately 1.050 planes of this type have been produced. This plane has two main landing gears so we estimate a use of two wheel carriers per plane which sums up to a need of 2100 parts over 22 years. The need of parts for the maintenance of the plane shall be discussed in the next chapter.

Other specific factors of the use of a part for the aerospace industry arise out of the high pressure to reduce operation costs of the plane. If you look at the kerosene price development for example, the price of a ton of kerosene is five times more expensive than ten years ago and costs nowadays around 1000 US$/[Inde13].
The significance of the fuel efficiency has raised so much in the last 10 years that the German Lufthansa has included the key performance indicator “fuel efficiency” in their operative company planning as the only non-monetary value [Luft12a].
The aspect of the possibility to reduce weight through the use of Additive Manufacturing has been proven regularly and will foster the usage of this technology in the future, as there is a strong connection between weight savings and the total fuel consumption of the vehicles. Lufthansa claims to spend 20 % of their total economic expenditures (7,4 bio. €) for fuel costs. There are plenty of models to calculate influence of weight savings in relation to fuel reduction. The differences in these models show the complexity of this topic. The best-known comparison comes from Karl West who claims a cost reduction of 3000 US$ per year and plane regarding one kilo of saved weight [West11]. These costs vary strongly depending on the number of starts, landing and total flight kilometers. This work will further consider a publication of Lufthansa claiming that based on an average flight length of 2004 km 0,041 kg of kerosene can be saved for every kilogram of weight savings [Luft12a][Luft12b].

In addition, the need for the reduction of carbon efficiency will become more important in the future. The aerospace industry has agreed upon a reduction plan of carbon emissions. The carbon emissions shall be reduced by 50 % from 2005 till 2050 [Kind13]. The reduction of one ton of kerosene is supposed to reduce the CO2 emissions by 3,12 tons [Frie07]. In Europe every ton of carbon emission needs to be balanced by emission-certificates. The price of theses certificates is around 3 € at the moment while the aim of the European union was originally 30 €. Currently these certificates do not appear for the aerospace industry due to strong complaints of the industry. As this will not be a long-term agreement these costs will be considered in the further calculations.

The combination of these two major aspects will play a key role in the evolving technology of AM and will help to foster the broader use of additively manufactured parts. These two aspects play a major role in the later distribution of the total lifetime costs of the spare parts.

Development of application scenario - Efficiency - supply chain and spare part logistics

For economic reasons, the downtime of an aircraft should be as short as possible. So not only newly produced parts need to be considered but as well the parts, which will be needed in the later use of an airplane. AM can play a significant role in this sector , too. To further detail this aspect the following parts will help to understand the impact of AM on the supply chain and on the costs.

It is estimated that an unexpected aircraft on ground costs 100.000€ a day [Göpf12]. Next to an appropriate scheduling in advance and an efficient maintenance work, it is mainly influenced by the availability of repair parts. This, however, includes highly complex and also a tremendous amount of specific components. The Lufthansa Technik AG e.g. stores approximately 420.000 different spare parts [PfTr05] and SR Technics approximately 400.000, including parts worth a few US$ cents but also engines worth US$ 5 million. [Alte08] On the one hand, one should provide sufficient repair parts to ensure the aircraft´s airworthiness, while on the other hand one should consider the costs rising with the amount of stored repair parts. The worldwide stock of spare parts is expected to have a value of US$ 20-30 billion and the annual costs for the storage of repair parts are expected to be 22 % of the acquisition value. These costs can be divided up into cost of capital, cost for warehousing, documentary, insurance and taxes and costs due to the excess of age of the components, approval renewal, damage or theft. [PfTr05]

Before AM-machines replace entire warehouses, it is conceivable that chosen parts are subject to the production on demand. Technical limitations as well as economic reasons, however, constrain the number of parts that could be manufactured additively. In respect of spare parts logistic, research work would be improved if a greater insight into an aeronautic spare part warehouse could be gained and suitable parts examined.

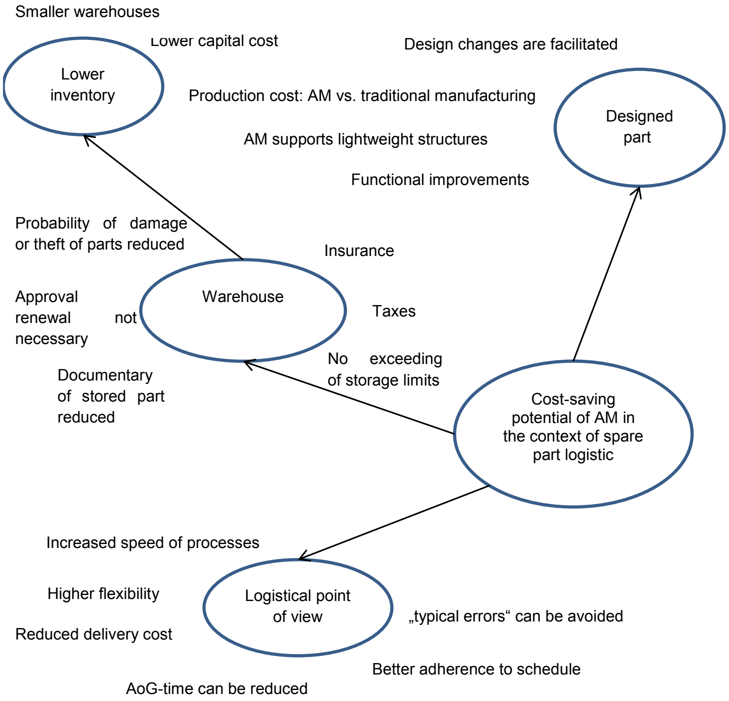
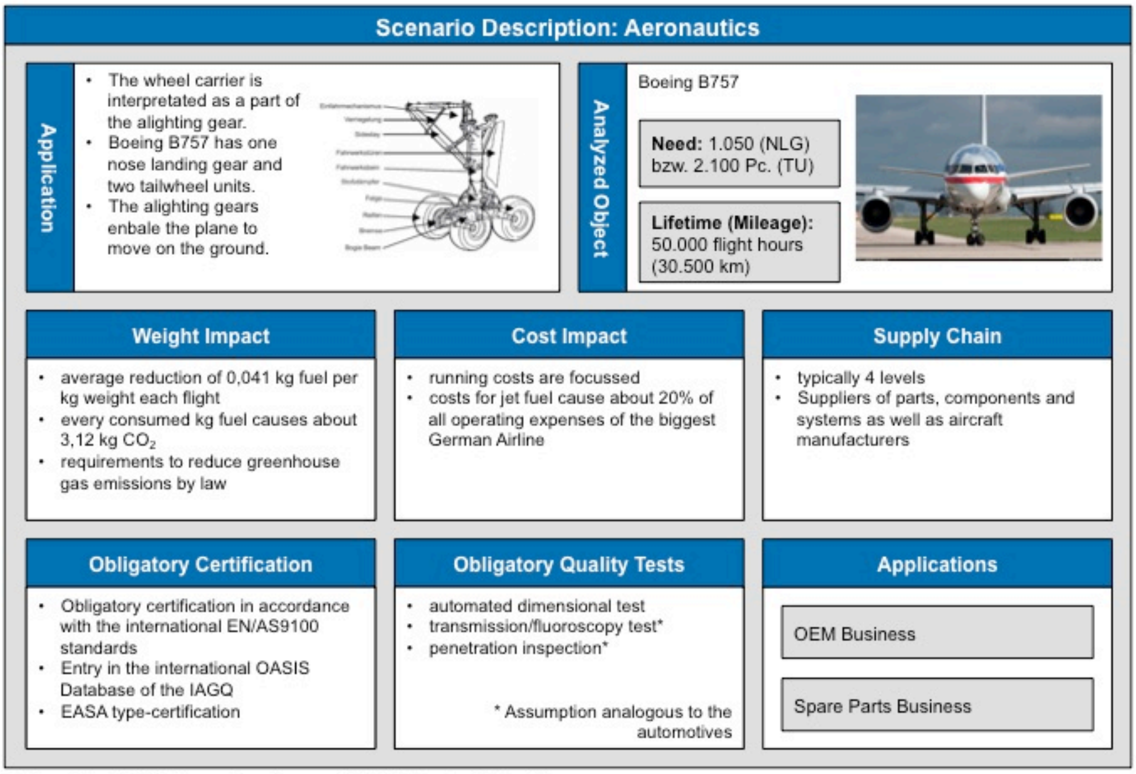


figure 3:Cost-saving potential of AM in spare part logisti

Further detailed research will be carried out in the European project RepAIR. Regarding the challenges of spare parts logistic, this work reveals that AM has the potential to overcome most of these challenges. However, it has to be taken into account that current disadvantages as explained in the state of the art have to be addressed. Moreover, it is presented which cost savings could be achieved if AM machines would replace large aeronautic warehouses. Based on the examinations in this work, future papers could pick up on every single potential cost saving and analyze the influence in greater detail. It would enable spare parts providers to understand the capabilities of AM better and thus research activities in this field could be intensified and improved. On top of that, a future maintenance-organization structure where the logistic department is replaced by a production department is worked out. Further research activities have to focus on how prospective business models including AM might look like.

Sample for an Application Scenario Profile

Figure 4 shows the final application scenario profile for a landing gear part from the aerospace industry. It summarizes the above mentioned points. It takes some time to develop these description and it needs to be done carefully as many factors have an impact on the costs. Interviews with potential AM users will help to specify the exact needs and to be able to develop application scenarios.



Scenario Description: Aeronautics

Application

- The wheel carrier is interpretated as a part of the alighting gear.
- Boeing B757 has one nose landing gear and two tailwheel units.
- The alighting gears enbale the plane to move on the ground.

Analyzed Object

Boeing B757

Need: 1.050 (NLG) bzw. 2.100 Pc. (TU)

Lifetime (Mileage): 50.000 flight hours (30.500 km)

Weight Impact

- average reduction of 0,041 kg fuel per kg weight each flight
- every consumed kg fuel causes about 3,12 kg CO_2
- requirements to reduce greenhouse gas emissions by law

Cost Impact

- running costs are focussed
- costs for jet fuel cause about 20% of all operating expenses of the biggest German Airline

Supply Chain

- typically 4 levels
- Suppliers of parts, components and systems as well as aircraft manufacturers

Obligatory Certification

- Obligatory certification in accordance with the international EN/AS9100 standards
- Entry in the international OASIS Database of the IAGQ
- EASA type-certification

Obligatory Quality Tests

- automated dimensional test
- transmission/fluoroscopy test*
- penetration inspection*

* Assumption analogous to the automotives

Applications

OEM Business

Spare Parts Business

Abbreviation list: NLG: nose landing gear; TU: tailwheel unit; Pc.: Pieces

Figure 4: Application Scenario Profile Aerospace for landing gear

Methodology to find verified AM part candidates

Finding appropriate parts for AM application has been complicated in the past as not enough knowledge is available and especially appropriate design rules are missing for the proper use of AM. Therefore, a methodology for finding appropriate part candidates needs to be developed as a first step for identifying appropriate parts. The methodology includes the application of the LCC model and needs to be performed by an AM expert. The methodology is split up into three different phases (compare figure 5).

It starts with an opening workshop to inform the potential end-user about capabilities and limitations of the technology. Different opportunities for successful AM application shall be presented in order to show opportunities and to break through existing thinking habits focused on traditional technologies, as in the past the one on one transformation of traditionally manufactured parts has not been shown to be optimal.

The presentation shall be supported by application profiles similar to figure 4 focusing on technical possibilities, technical solutions and on the economical merit of the successful application of AM (compare [LJM+12] for benefits). This phase has the aim to bring ideas in the heads of the designers in order to make them think about possible solutions for their company. It can be seen as a kind of creativity fostering workshop. Future studies like [GEW13] can help to discuss the future potential of the technology. Therefore, adequate points for the entrance in the technology can be defined.

For the second workshop the end user shall think about possible part candidates and define a list of specific applications and candidates. The part candidates will be discussed with the help of a value benefit analysis. Therefore, pre developed templates will be used regarding application / economic / and technical criteria. The pre-defined criteria can be weighted and completed by further factors important for a branch or a company. During discussion the characteristics will be developed. The top rated parts will be discussed again to find a starting point for application. The production costing model can help to give a first estimation of part costs.

In the verification workshop further details of the parts will be clarified. This includes discussions about technical changes and the total integration of a part into its environment. Aspects like functional integration can be discussed in this phase.
After the clarification of the part structure, an existing scenario profile can be adapted or a new scenario part profile can be developed for the usage of the part. Once completed, the results can help to identify the full potential of a solution. If the results of the analysis are negative for a certain candidate, the production values can be adapted again to future forecast of the technology. This can help to define the optimal point to reconsider the use of the technology.

Opening Workshop
- Presenting AM potentials and limitations
- Presenting case studies regarding :
  - Technical possibilities
  - Technical solutions (now and tomorrow)
  - Economical merrit

Part selection workshop
- Gathering information about part candidates
- Discussing advantages about part candidates
- Definition of important part criteria (application / economic / technological)
- Weighting of defined part criteria
- Part selection
- Estimation of production costs

Verification workshop
- Discussing technical changes or new design of part candidates
- Developmpment-/adaption of application scenario profile
- Calculation of LCC Costs (now and tomorrow)
- Decision on part candidates and development of production strategy

figure 5: Methodology for selecting AM part candidates

Sample part for further calculations

As a first sample to derive knowledge out of the developed models, a part which is used as an upright of a formula student racing car has been chosen. This upright was originally designed for milling (figure 6 left). One advantage is that it allows the view on two different branches. It is very similar to aerospace parts due to its high buy to fly ratio of 16.6 (94% scrap). On the right side of figure 6 the same part redesigned for AM can be seen. Supported by the Finite-

Element-Analysis a “buy to fly ratio” of 1.25 has been achieved. Finally, the weight of the redesigned upright is reduced by 40%. Assuming a small batch production, a cost reduction of 50% compared to the traditionally manufactured part has been achieved. This was done without producing polluting waste. A disadvantage is the manual and thus very extensive design process based on the FEA data. [LJK+13] Three other design studies will help to derive branch dependent knowledge in the future.

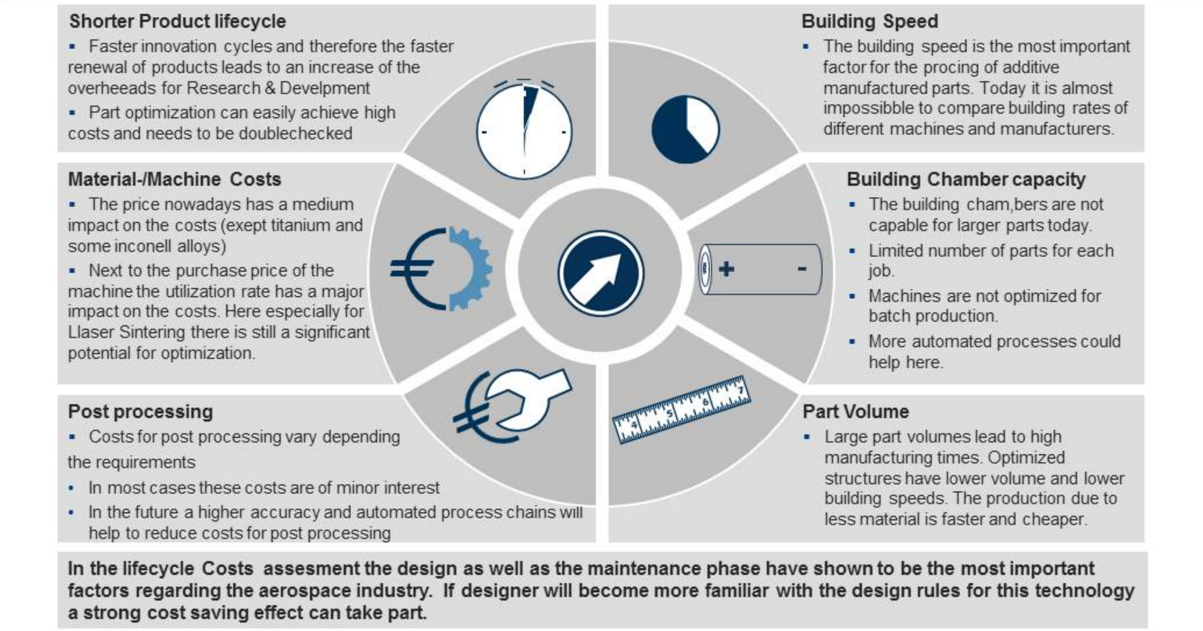
Figure 6: Redesign of an upright (left subtractive; right additive) Source: DMRC report 2012

The findings so far show that there are several major aspects which need to be improved before (M)AM can finally play out the technological advantages and can thus be accepted as an opportunity for batch production by the broader public. Adjusting current factors in the costing model based on expert survey [GEW12] showed cost reduction possibilities of over 50% for the future [LJK12]. As the machine costs are and will play the biggest part in this orchestra the building speed and the utilization rate will have to be improved for the future. At the moment, the character of the MAM still seems to have a wider optimization potential for batch production. To start with, software tools need to be developed. Preparation still consumes a significant amount of time. A major expertise is needed and an individual batch production is desired. In some trials human labor has consumed over 13% of the part costs.

Discussion of Results and further costing developments

The calculations conducted have shown that the two largest contributors to the Lifecycle costs occur from the design phase and from the operation and maintenance phase as well as from the production phase. This means an optimization of the operation costs has especially a major influence on the total lifecycle costs per part. The high costs for optimization have only been feasible for a higher number of parts produced. While the uses of the part in the racing team these costs have to be split on a production target of only four pieces. As the benefits from fuel savings are not as significant in this sector, the technology cannot shoe the full potential here. While the breakeven point between the optimized and the traditional design (both manufactured additively) lies around 250 pieces, the racing team scenario would need a production target of 425 parts in order to reach the breakeven point. In total, the additively manufactured parts have shown to be cheaper along the production chain. This effect will be enhanced if software tools will develop which can help to develop topology optimized parts with a lower amount of work. One AM machine would be able to produce 673 parts per year if considering a utilization rate of 75%. It seems that one machine would be capable to deal with the production targets of the aerospace industry over lifetime. Considering common production targets like in the automobile industry high numbers like 2.000.000 parts would appear. This would mean that one machine would need 2971 years or 29 years if 100 machines would only produce this wheel carrier regarding current technological possibilities.

In the considered scenarios the additive manufacturing of the wheelcarrier has shown to be cheaper as well in the production costs as well as in the lifecycle process. This shows that high complex parts like they are common in the aerospace industry have already the potential to be produce in series production with additive manufacturing. Even the material costs were lower for the additive manufacturing as a 16 kg Block of aluminum is the starting point and takes around 6 hour for the build. In comparison the material needed for the additive manufactured part only displays 0,72 kg. There one can see that even higher material prices can be cheaper regarding the application.



Shorter Product lifecycle

- Faster innovation cycles and therefore the faster renewal of products leads to an increase of the overheeads for Research & Develpment
- Part optimization can easily achieve high costs and needs to be doublechecked

Building Speed

- The building speed is the most important factor for the procing of additive manufactured parts. Today it is almost impossibble to compare building rates of different machines and manufacturers.

Material-/Machine Costs

- The price nowadays has a medium impact on the costs (exept titanium and some inconell alloys)
- Next to the purchase price of the machine the utilization rate has a major impact on the costs. Here especially for Llaser Sintering there is still a significant potential for optimization.

Building Chamber capacity

- The building cham,bers are not capable for larger parts today.
- Limited number of parts for each job.
- Machines are not optimized for batch production.
- More automated processes could help here.

Post processing

- Costs for post processing vary depending the requirements
- In most cases these costs are of minor interest
- In the future a higher accuracy and automated process chains will help to reduce costs for post processing

Part Volume

- Large part volumes lead to high manufacturing times. Optimized structures have lower volume and lower building speeds. The production due to less material is faster and cheaper.

In the lifecycle Costs assesment the design as well as the maintenance phase have shown to be the most important factors regarding the aerospace industry. If designer will become more familiar with the design rules for this technology a strong cost saving effect can take part.

figure 7: Further findings during costing analysis

In the study “Thinking ahead the future of Additive Manufacturing – Innovation Roadmapping of Required Advancements” [GEW13] the authors have conducted a survey amongst 150 industry experts on the future development of additive manufacturing. The aim was to have a consolidated picture of the realization time of possible technical advancements in the fields of AM. The study was divided into MAM and Selective Laser Melting powder bed processes as well as FDM Processes.

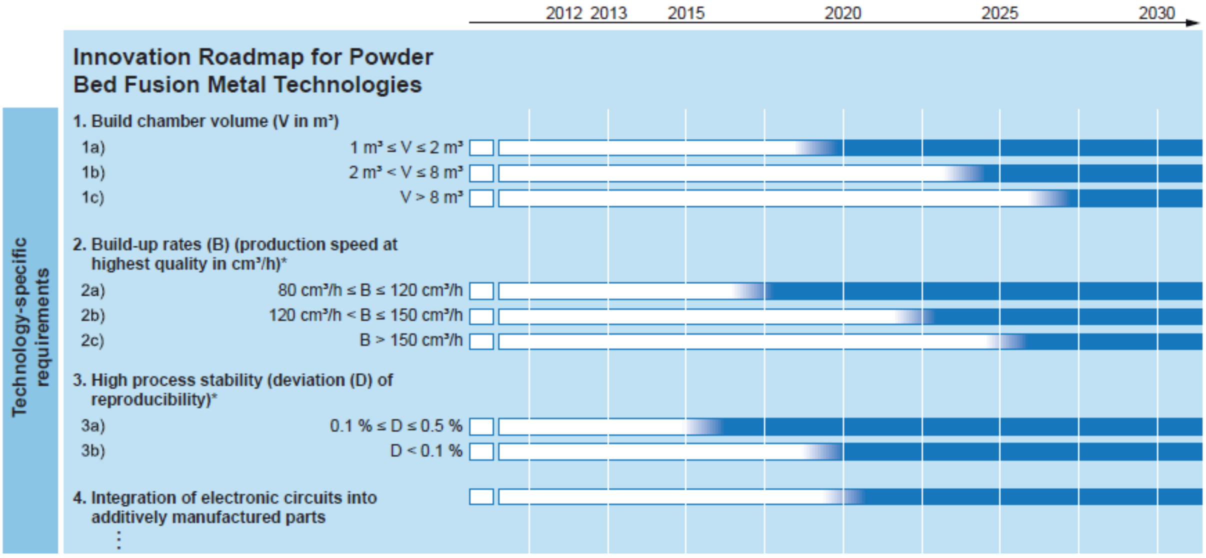


figure 8: Excerpt of the study "Innovation Roadmapping of Required Advancements"

As indicated in the paper [LJM+12] the build rate, the machine costs and the material costs as well as the utilization rate have been identified as most critical factors regarding AM production costs. Some potential has been seen for the optimization of pre and post processing of the building job as well [LJM+12].

The development of some of these factors (compare figure 8) has been investigated in the future study. As

realistic measures, building rates of up to 120 cm^3/h and build chamber sizes up to 2 m^3 have been predicted feasible for 2020 (see figure 7). These strongly affect the costs of the build for the future [GEW13]. Assuming these possibilities and assuming a strong regression of material prices one can easily predict a higher accuracy for the technology in the future.

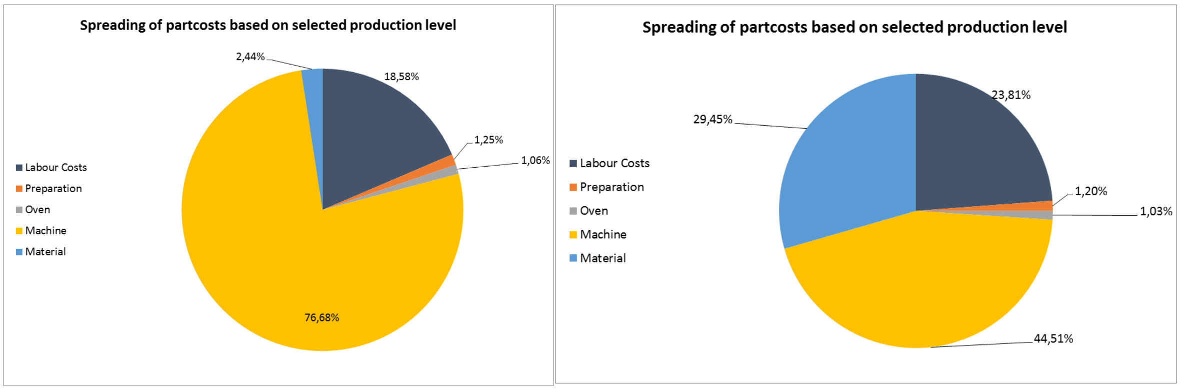


figure 9: Spread of costs for producing the wheelcarrier today (left) and in 2020 (right)

If the experts are right, in 2020 the total price of the sample part will drop by 90% in comparison to today's manufacturing costs. As one can see in figure 8 the total distribution of the costs will change then. As the portion of the machine rate costs go down significantly other factors like material prices gain a lot more significance. This calculation estimates that the machine costs will not drop significantly in the next years as the performance and the quality control systems undergo a permanent development.

Conclusion and Outlook

An appropriate part selection and the understanding of the costing structure during product lifecycle will help to foster the spread of AM already nowadays.

The future development of the technology predicted by experts shows a major cost reduction potential in the next seven years. This will help to widen the application fields. The enlarged build volumes will help to make AM feasible for small batch productions and increase the efficiency. Furthermore, the larger building volumes in combination with higher build rates widen the application fields to larger parts of different industries as well. Large parts offer even higher weight reduction potential for the lifecycle. This is important to achieve the ambitious efforts in reaching the described carbon efficiency goals. The build rate increase will make the technology by far more competitive with other technologies and broaden the application fields to areas which are not feasible nowadays. The sample part has shown that different design approaches lead to different results in lifecycle costing and production prices.

The direct conversion of topology optimized into STL or in the future AMF parts will save a huge amount of money in the concept phase and make it more attractive to use. Then, the technology will be able to easily outperform traditional manufactured parts in some areas. Nowadays the regression effect of the optimization regarding small production numbers limits the use of the topology optimization in a major way. The knowledge of appropriate design rules (currently developed in the project "Direct Manufacturing Design Rules") in combination with available material data and fresh educated engineers will strengthen the trust in the technology and therefore foster the further spread of AM.

The presented model only represents theoretical aspects and has been a result of intense literature research to complete all data for the application scenario profiles. The methodology will be further developed as a web based tool for costing calculation and part comparison. The conversion into a proper IT-system will help to reduce the manual input in the system and allow a more detailed calculation. The whole calculation tool is constantly under refinement. The further compatibility of build rates is one important topic for the future as well. Currently the build rates of different machine manufacturers are not comparable at all. Especially as the build rate is a factor which is especially dependent on the machine- material- and product-combination. These rates need to be made comparable and shall be published by the machine manufacturers for each machine material combination.

In the EU-FP7 project “RepAIR”, “Future RepAIR and Maintenance for Aerospace industry Onsite maintenance and repair of aircraft by integrated direct digital manufacturing of spare parts” the part selection methodology and the assessment of real cost for MRO processes will be researched. Furthermore, different business models will be developed and compared monetarily to find out about the total impact of AM on the supply chain and on different production models. These investigations will be performed in parallel for the opportunities of AM to redesign and to produce parts for new satellite structures. Then, the influence of functional integration will be part of the research, too. Based on the results of today’s manufacturing possibilities of these two applications future chances and scenarios will be defined in a study.

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