Bachelor Thesis

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Title:

"Market Usage Gap Analysis – Market Potential, Target Group Classification and Penetration Strategy for Large Scale Fused Filament Fabrication Machines in Germany"

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Abstract

This thesis analyzes the German market for large scale fused filament fabrication devices to derive strategic implications for a penetration of this market with a device of a build size of 1000x1000x1000 mm. It gives an overview over the current state of fused filament fabrication and shows that the market is growing, manufacturers and (potential) customers are increasing in number.

Currently available devices are classified by build size and in due process competitors in the large-scale segment are identified. A survey of 750 companies, creating 110 total responders, is undertaken, showing that the adoption rate of additive manufacturing in the targeted segment is higher than found in secondary sources, with the Industrial-Product- and Fashion -design branch having the highest adoption rate. Furthermore, it shows that build speed and detail level, and after sales service such as personnel training and device installation and set-up are important to potential- and current users. Aiming at a specific target group, the size of that market segment is quantified. An existing demand for large build size machines is shown and the Industry Market Potential for large scale devices estimated. From this, a market usage gap of 1023 units is derived. In concluding, the recommendation to penetrate the market with a technological focus on build speed and detail level and an emphasis on customer service is made.

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II Glossary

3D-Printing: See “Additive Manufacturing”

Absolute Market Potential: The maximum of market size under the assumptions that everyone who could use the product has it in use, every user is using the product every possible time and on each use occasion, the product is used to its highest degree (Lambin & Schuiling, 2012, p. 215, also Weber, 1976, p. 145).

Additive Manufacturing [AM]: Direct creation of a three-dimensional object from a data file (Roland Berger, 2013, p.7)

Build Size: Maximum size of an object producible by a 3DP system, given in three axes (width, length, and height).

CHAID, Exhaustive: Statistical analysis for ordinal or continuous variables, based on CHAID in which for every predicting variable all possible solutions are tested (Brühl, 2014, p. 696 & p. 739).

Chi-squared Automatic Interaction Detection [CHAID]: Statistical system by which the correlation of independent variables is analyzed based on Chi-squared tests (Brühl, 2014, p. 696).

Compound Annual Growth Rate: Annual mean rate of revenue growth between two years, under the assumption of a growth rate that is exponentially compounded (Gartner, 2017)

Exhaustive CHAID: See “CHAID, Exhaustive”

Industry Market Potential (IMP): “IMP equals the number of relevant consumers times the number of use occasions that arise per relevant consumer per operation period (usually one year)” (Weber, 1976, p. 58).

Powder Bed Fusion: An electron beam or a laser are used to selectively fuse layers of a powdered building material (Wohlers & Caffrey, 2014, p. 35)

Selective Laser Melting: See Selective Laser Sintering

Selective Laser Sintering: Additive manufacturing process in which lasers create hardened layers of powder-based build materials layer by layer (Gebhardt, 2013, p. 59)

Stereolithography: Additive Manufacturing process in which liquid monomers are hardened by "...(Photo)-Polymerization" (Gebhardt, 2013, p. 47)

Subtractive Manufacturing: A manufacturing process in which the desired shape is created by removing material in defined positions and amounts from a semi-finished or unfinished part (Gebhardt, 2013, p. 1).

VAT Polymerization: Rapid Prototyping / Rapid Manufacturing process where a focus of ultraviolet light is used to selectively cure an ultraviolet-receptive resin in a vat for polymerization layer by layer (Wohlers, & Caffrey, 2014, p. 33)

III List of Abbreviations

3DP: 3D-Printing

ABS: Acrylonitrile Butadiene Styrene

AM: Additive Manufacturing

AMP: Absolute Market Potential

BMF: Bundesministerium der Finanzen

CAGR: Compound Annual Growth Rate

CHAID: Chi-squared Automatic Interaction Detection

CNC: Computerized Numerical Control

Comp.: Compare

Destatis: Statistisches Bundesamt

FDM: Fused Deposition Modeling, see "FFF"

FLM: Fused Layer Modeling, see "FFF"

FFF: Fused Filament Fabrication, also referred to as Fused Deposition Modeling [FDM] or Fused Layer Modeling [FLM]

IMP: Industry Market Potential

LS: Laser Sintering

N.D.: No Date

P: Percentile

PD: Percentile Distance

PLA: Polylactic Acid

PWC: PriceWaterhouseCoopers

SABL: Statistitsche Ämter des Bundes und der Länder

SL: Stereolithography

SLM: Selective Laser Melting

SLS: Selective Laser Sintering

USPTO: United States Patent and Trademark Office

VAT: Abbreviation for VAT Polymerization

WZ2008 Code:

Witschaftszweige 2008 - Classification of economical branches according to Article 8 (EG) No. 1893/2006[1]

YTC: Young Technological Company

[1] http://eur-lex.europa.eu/legal-content/DE/TXT/?uri=CELEX:32006R1893

1 Introduction

1.1 Objective of the thesis

The goal of this work is to verify the strategic opportunity of supplying plastics based additive manufacturing [AM] / rapid prototyping machines with a build size of 100x100x100 cm to the German market, aiming at the target groups of foundries and small engineering companies, designers and craftsmen, architects and others. The underlying thesis being that a) those companies have a use for AM in general and Fused Filament Fabrication [FFF] with its available materials in particular, and b) there is a demand for large build sizes. The supplier scope is from a new company, aiming to enter and penetrate this market with a single device. Secondary research is undertaken with the goal to estimate the markets demand for large scale devices as well as to identify competing suppliers and potentially other devices in this build size range. By using primary research to gather information about the companies AM usage, it is attempted to group them depending on their AM use to allow for specific targeting and to derive strategic implications for a market entry / penetration, the underlying thesis being that target companies can be classified by common factors, e.g. type of business and number of employees, and by using a Chi-squared Automatic Interaction Detection Analysis [CHAID], identifying those companies that have a potential for using these devices and derive strategic implications for a market entry.

1.2 Course of Investigation

Chapter two provides a technical overview of rapid manufacturing processes with focus on FFF as well as an outline of applications of rapid manufacturing necessary to follow the analysis in chapter three and four and theoretical background on the market usage gap and market potential. Wherever specific information hast not been found by the author, or was not accessible for e.g. financial restrictions (purchasing price and unavailability of literature for lend), second hand sources quoting the originals are used or assumptions are made and identified as such as a field of further study (table 18, appendix p. XVII).

In Chapter three, a market analysis is undertaken to identify the current state of the German market and an overview of identified rapid manufacturing devices with focus on FFF is given. With information gathered in these chapters, the demand for primary research in chapter five is developed.

Chapter four consists of the strategical part, giving an overview of business strategy and market orientation. Best practice examples based on successful market entrants are utilized to show viable strategic orientations for market penetration.

Chapter five contains primary research with a survey of potential customers with the goal identify common factors for potential customers for large scale FFF devices using a CHAID-analysis. Also, this survey is used in an attempt to generate information that was not available via secondary research. Furthermore, with the gathered data, the previously estimated market potential is improved and the market usage gap is presented.

Chapter six concludes, summarizes the findings of chapters two to five, presents a recommendation for strategic market positioning, sets this work into scientific perspective and provides an outlook into possible further research.

1.3 Actuality of Additive Manufacturing

Three-dimensional printing [3DP] is close to a mainstream breakthrough (D'Aveni, 2015) and according to a study by PriceWaterhouseCoopers [PWC] in 2014, 59% of small companies (below 500 employees) are beginning to use AM to some degree, ”...adopting 3DP in some way (Experimenting to determine how they might apply it, or using it to prototype products or producing final products)” (PWC, 2014, p. 8). In the next years, a shift in value chains is expected, transforming the sale of produced goods to the sale of production plans and production rights for 3D printed objects (D'Aveni, 2015). The global market for printers is expected to grow from $2.2 billion in 2012 to $6 billion by 2017, with a projected 98.000 printers in the price range below $100.000 sold in 2017 (PWC, 2014, p. 1). The number of patents granted for Additive Manufacturing have tripled from 2010-2013 (D'Aveni, 2015).

It is this fast growth and the potential of 3DP that is the basis for the actuality of the issue. Figure one illustrates the rapid increase in scientific literature about 3DP and AM in general, while simultaneously showing a lack of economics and business literature dealing with FFF in particular. Note that while publication figures for 2016 are already exceeded in 2017, the latter does not represent a full year as the publication numbers are as of 12.07.2017.

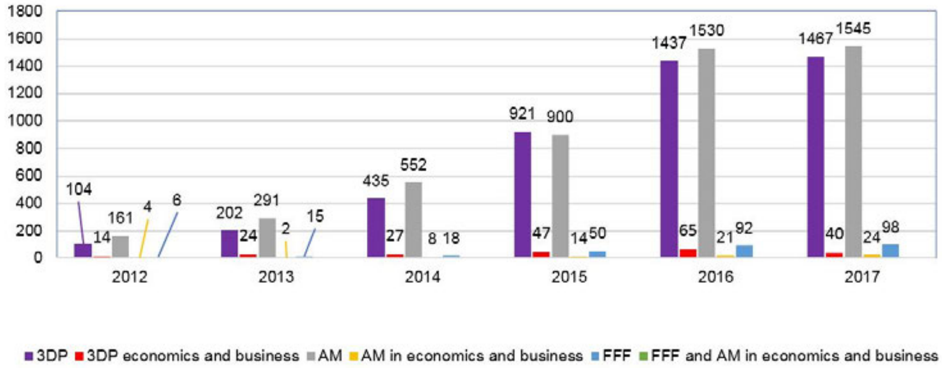

Figure 1 - Occurrence of AM and FFF in general and economics and business specific journals
Source: Own compilation based on sciencedirect.com, 2017

2 Theoretical and Technical Background

2.1 Theoretical Background

2.1.1 Market Usage Gap

Gap analysis is used to determine the difference (gap) between the Industry Market Potential [IMP] and the actual sales in that market (Lambin & Schuiling, 2012, p. 230, also Weber, 1976, p. 145). Also referred to as Absolute Market Potential [AMP], IMP and AMP define the maximum of market size under the assumptions that everyone who could use the product has it in use, every user is using the product every possible time and on each use occasion, the product is used to its highest degree (Lambin & Schuiling, 2012, p. 215, also Weber, 1976, p. 145). In this model, a given firm is thought to have potential maximum sales equal to the IMP (Weber, 1976, p. 59). IMP is the sum of current firm's sales, the “Competitive Gap”, the “Usage Gap”, the “Distribution Gap” and the “Product Line Gap” (Weber, 1976, p. 59). The Distribution Gap exists due do a lack of distribution in either subcategory as coverage gap, intensity gap or exposure gap (Lambin & Schuiling, 2012, p. 230). The product line gap is due to inadequacies in the product line and can be size-, options-, form-, or style and color related as well as due to sales via distributor brands and completely missing segments (ibid., pp. 230-231). Within this framework, three types of usage gap are differentiated by literature. Figure two is used to visualize these gaps.

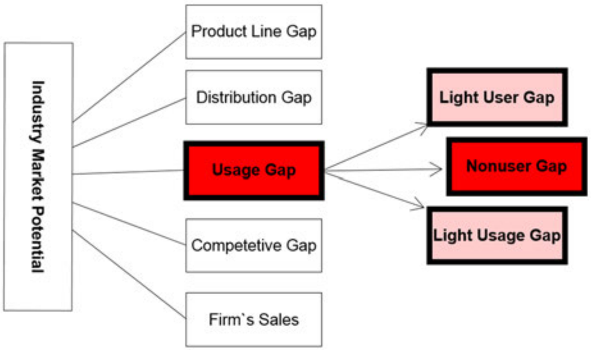

Figure 2 - Illustration of Industry Market Potential and Respective Market Gaps
Source: Weber, 1976, p. 59 (own adaption)

The “Nonuser Gap” contains the number of users who could potentially use the product but are not currently doing so (Weber, 1976, p. 146). In the “Light User Gap” the number of users who do utilize the product but not on every possible use occasion is found (ibid., p. 147) and the “Light Usage Gap” contains those users that use the product on every possible occasion but not to its maximum usage potential in each use (ibid.). **Assumption (1):** Since 3DP machines are not consumables, for the current perspective it is not relevant if, when used, they are used to their full potential or at any given opportunity, thus in the course of this work, focus is laid on the usage gap in its entity.

2.1.2 Market Potential

According to WEBER, the “Industry Market Potential [IMP] for one use of a product equals the total number of units of the product that could be consumed during one operation period (e.g. one year) if the product were consumed in a full reasonable dose every time a “use occasion” occurred” (Weber, 1976, p. 63).

Under the **assumption (2),** that end users of 3DP machines behave as consumers would towards a long-lasting consumer good, a calculation presented by Lambin et. al is used to estimate primary demand (Lambin et al., 2007, p. 158) as basis for the IMP.

Primary Demand (Q) equals first equipment demand plus replacement demand (ibid.). This is detailed as follows: $Q = [(N * \Delta e) + (\Delta N * e)] + [t * (s + \frac{1}{v})]$. Table one illustrates the definition of variables:

Variable	Definition
N	Number of consuming units [number of potential buyers]
Δe	Increase of equipment rate
Δn	Net change of consuming units [number of potential buyers]
e	Equipment rate [units per buyer]
t	Size of device population
V	Average lifespan of the device [in years]
S	Substitution rate

Table 1 - Definition of Variables for IMP calculation
Source: Lambin et. al., 2007, p. 158 (own adaption)

By inserting maximum values for variables e, Δe, s and v, the IMP can then be calculated (Lambin et. al., 2007, p. 158). This formula is applied in chapter 3.3.

2.2 Technical Background: Large Scale Fused Filament Fabrication Devices

2.2.1 Fused Filament Fabrication

AM has been used since the 1980's for prototyping to grant feedback during the product development process (rapid prototyping). However, recently direct manufacturing has come into focus (Gibson et.al, 2015). It offers one-step production of functional items, even with high complexity such as cavities for cooling and heat dissipation, eliminates the need for tool manufacturing, allows users to change designs without an increase in costs, allows for “High manufacturing flexibility: objects can be produced in any random order without cost penalty” and decreases raw material demand by reducing scrap (Weller et. al., 2015, p. 46). One of the major advantages of additive manufacturing lies in the ability to produce geometrically complex parts and simultaneously eliminating the need for final assembly and machine set-up (Astor et. al., 2013, p. 35). AM processes vary in the range of speed, object size and availability of materials and must be looked at in a differentiating perspective to avoid generalizing the subject (Weller, 2015, p. 51)

Fused Filament Fabrication [FFF], also referred to as Fused Layer Modeling [FLM] are generic terms for the commonly used Fused Deposition Modeling [FDM], which is a trade mark of the US-based manufacturer Stratasys (Gebhardt, 2013, p. 70, also Hiermenz, 2011, p. 5). In the FFF-process, a heated nozzle adds molten building material in consecutive layers, which hardens as it cools (Astor et. al., 2013, p. 37).

For this process, materials with a low thermal conductivity, such as plastics and wax may be used (Gebhardt, 2013, p. 71). Layer thickness varies between devices starting at 0.33 mm, reaching down to 0.13 mm (Hiermenz, 2011, p. 2) or 0.078 mm for high accuracy machines (Gibson et. al, 2015, p. 162), while utilizing lower layer thickness will increase build time (ibid., p. 164).

2.2.2 Applications and limitations of FFF-Based Devices

AM in general is mainly used to produce functional parts, with 29% of applications, followed by prototypes in the assembly and fitting process with 19.5% (Wohlers & Caffrey, 2014, p. 20). Further applications include patterns for prototyping and tooling (10.9%), patterns for metal casting (9.5%), presentation models (8.7%), visual aids (8.7%), education and research (6.1%), tooling of components (5.6%) and other applications (2%) (ibid.). Current research shows FFF to be used for concept models and haptic samples, fully usable prototypes as well as custom made tools and finished goods (Hiermenz, 2011, pp. 4-5). Especially, there is a trend to use this technique for final products and parts at low manufacturing volume such as structural components (Manyika et. al, 2013, p. 107) and also for rapid prototyping (Gebhardt, 2013, p. 329), in due process speeding up product development and time-to-market (Thewisen et. al., 2016, p. 3). Current large scale FFF device enable the extrusion of whole engine blocks and usable, full size furniture (Titan Robotics, 2017). Recent introduction of multi-extruder head printers has negated limitations on material and build speed, allowing simultaneous use of different materials, mixed colors as well as the use of water soluble support materials (Titan Robotics, 2016a). Stratasys, who offer a manufacturing service for 3DP-goods, see a development from their orders being formerly prototype based towards now consisting to 65% of ready to use products or molds thereof respectively (PWC, 2014, p. 4). A limiting factor for the application of the extruding process is the limit to which details can be reproduced due to filament thickness and nozzle diameter, thus also limiting the minimally achievable wall thickness of the workpiece, as well as available build space and the demand for surface quality (Gebhardt, 2013, pp.94- 97), as additional surface finishing may be required (Weller et. al., 2015, p. 46). Furthermore, only minimal economies of scale occur with AM, decreasing its competitiveness to conventional manufacturing with increasing lot size (Weller, 2015, p. 97).

3 Market Potential Analysis of the German Market for Large Scale Fused Filament Fabrication Machines

The purpose of this chapter lies in creating an overview of the current state of the FFF-Market in Germany. Utilizing secondary literature as well as information directly from 3DP machines manufacturers, it provides necessary information about the general size of the market, major competitors and expected market development, deriving market potential. Market potential is derived by using a deductive process, based on premises and available market information, obtained from the Statistisches Bundesamt [Destatis] and other sources.

3.1 Analysis of the Current Market and Available Devices

Identifying competitors in industries is essential for defining a market while from a marketing perspective "..it supports the analysis of pricing policies, product design, development and positioning, communication strategy and channels of distribution" (Bergen & Peteraf, 2002, p.158), and competitors can also be identified by examining and contrasting their available resources and capabilities (Peteraf & Bergen, 2003, p. 7). In due course, competitors are identified based on dimensions relevant (Bergen & Peteraf, 2002, p.170). By questioning whether the companies compared are able to satisfy the same customer demand, currently or in the future, competitors can be identified (ibid.) and analyzing resource similarity is defined as "…the extent to which a given competitor possesses strategic endowments comparable, in terms of type, to those of the focal company." (ibid., p. 161), a competitor identification matrix can be created. To identify competitors, supply as well as demand side must be considered, by analyzing product similarity and thus substitutability [demand] as well as technical capabilities of competing firms [supply] (Bergen & Peteraf, 2002, pp. 158-159). As "…product substitutes may not be similar to one another on a superficial basis, they are similar in terms of their use" (Peteraf, Bergen, 2003, p. 2).

3.1.1 Existing Devices and their Properties

Data sources are, if not denoted otherwise Wohlers & Caffrey, 2014, pp. 254-267 and the respective manufacturers' website. A selected list of data sources is found in the appendix under "Sources for Market Analysis", the complete file with all data sources is found in the "Digital appendix". Since the scope of this work is put onto specific devices, not their respective manufacturers, available machines are analyzed and compared according to their likeness relating to device properties. For analyzing resource similarity and strategic endowment, the following criteria are available: Country of origin, manufacturer, system type, and model.

Materials are condensed as follows: PLA, ABS, polymers, and acrylates are classified as "plastics", all ferrous and non-ferrous metals are classified as "metals", precious metals, sands, foodstuff, and other materials are classified as "others".

In Total, 104 manufacturers of additive manufacturing machines are found, selling 439 different machines. Of these, 247 machines use plastics, 49 metals and 143 other materials. Of these machines, 95 utilize the VAT process and 188 material extrusion or FFF, providing a total of 283 machines for comparison. Detailed frequencies tables illustrating the frequency of manufacturing processes ("Type") and material classification ("Material Class)" are found in the appendix in tables nine and ten, p. XIV in the appendix.

For this research, all plastics based systems functioning with either VAT, or material extrusion are handled as comparable. Due to the proposed large-scale device, machines with a build volume of less than 139 liters, as well as build volumes exceeding 1500 liters are excluded. Sizes are defined by the device axis: Build length = Y-Axis, build width = X-Axis, build height = Z-Axis, build volume in liters [l] as the product of the axis values. This is used as an index for total build volume (index: comp. Berekhoven et, al, 2009, p. 72).

3.1.2 Competing German Based Companies

The WOHLERS REPORT 2014 provides eight companies manufacturing 3D printers for non-personal use (Wohlers & Caffrey, 2014, pp. 256-259), while none of these were providing FFF devices and four of those offering systems with non-metal materials (ibid.). By 2017, the total number of companies has increased 23, with 13 of those offering FFF based machines, with eight of those companies offering devices with a build volume exceeding 125 liters [thus a theoretical build room of 500*500*500 mm or larger] however, no turnover figures are available (own compilation)[2]. The following competing companies are found, all offering FFF based devices: About3D, BigRep GmbH, Fabru GmbH 3D Printing Solutions, F&B Rapid Production GmbH, German RepRap GmbH, Membino GmbH, and Multec.

3.1.3 Globally Competing Devices

From a global perspective, assuming an availability on the market, 34 devices by the following companies are identified as providing FFF based systems exceeding 125 liters of build volume: Ion Core Technology Ltd. (Great Britain), Builder 3D Printers B.V (Netherlands), Hage (Austria), Opiliones (Netherlands), Stratasys (Israel), and Titan Robotics (USA).

As likeness may not be evident from the product [machine] but also from the way it is used (Peteraf & Bergen, 2003, p. 2), customer needs are identified by the index build volume. Devices are filtered to allow for the aimed device size and device type, thus encompassing all devices matching the classification of build volume and material class “plastics”.

The index build volume is separated manually in five classes. The class ranges are given as follows with the average build volume in liters in each class in square brackets (1) 139 to 172.8 l [148.9 l], (2) 172.9 to 234 l [210.1 l], (3) 234.1 to 343 l [282.9 l], (4) 343.1 to – 618.8 l [l], and (5) 618.9 to 1.500 l [948].[3] Note that class five contains the intended device size.

Country of origin is separate in three factors expressing their geographical distance from the German target market, ranging from (1) for German [domestic], over (2) for European Union and up to (3) International.

The data and analysis results are transferred into a competitor identification matrix, based on Bergen & Peteraf, 2002, p. 162, and illustrated in figure three, separating the devices into three classes of competitors. High direct competitors, competing with the same device class from the same origin are case 198 BigRep GmbH, “BigRep ONE”, and case 199 “Elephant One”, 3D Elephant. As potential competitors with the same device class and European origin case 256 Builder 3D Printers B.V, with the “Extreme 2000” are identified, and potential indirect competitors in the same device class and

[2] Data based on Wohlers & Caffrey, 2014, pp. 254-267 and respective company website

[3] Frequency Table: Table No. XX; mean value of each class: Table No. XX

international origin are cases 348 and 349, both from Titan Robotics, “Atlas 2.5” and “Atlas 2.0”. The closer two given devices are on the Y-axis, the closer they are geographically. The distance on the X-axis expresses the build volume equivalence, a larger distance indicating a larger difference in build volume.

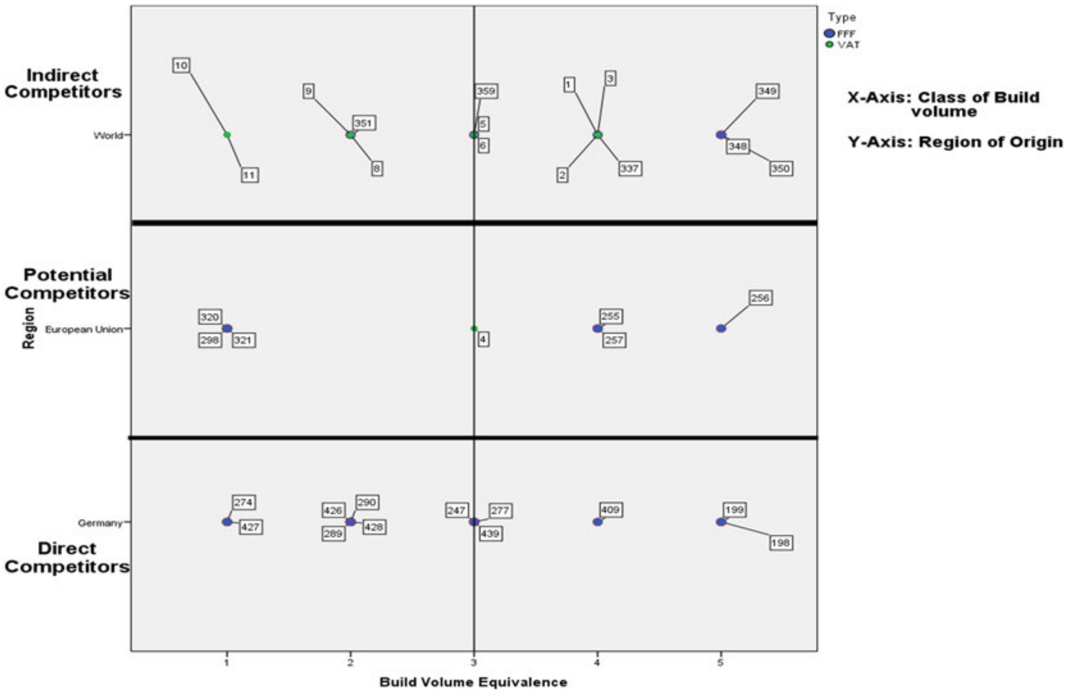

Figure 3 - Product Based Competitor Identification Matrix
Source: Own creation based on Bergen & Peteraf, 2002, p. 162 and Lambin & Schuiling, 2012, p. 256. Data from Wohlers & Caffrey, 2014, pp. 254-267, and respective company website, details in the appendix under “Sources for Market Analysis”

3.2 Market Development for 3DP

The global market for additive manufacturing devices and services showed a compound annual growth rate [CAGR] of 34.9% to a volume of $3.07 billion in 2013 with 9.832 units sold in the professional range (exceeding a sales price of $5.000) and a CAGR of 32.7% to a volume of $2.275 billion in 2012, and a CAGR of 29.4% for 2011 respectively (Wohlers & Caffrey., 2014, p. 109, also ibid., p. 117). In an expert survey in 2011, the market penetration rate was estimated at 8% (ibid., p. 115). FDM [FFF] ranked third as “most profitable technology” for service providers in 2010 at a response rate of 14.3%, superseded only by Laser Sintering (18.4%) and Stereolithography (36.7%) in 2010 (Wohler 2010, p. 48) and in 2014 FDM kept the same position with an increase to 15.4%, superseded by Laser Sintering at 25.6% (Wohler & Caffrey, 2014, p. 135). Furthermore, FFF no longer is protected by patents. US patents have a protection time of 20 years after the date of filing (USPTO, n.d.), hence the protection on the general deposition principle expired in 2009 [Patent US5340433 from 30/10/1989] (Stratasys, 1989) and the patent on FFF printing with support material via a second extruder head in 2014 [Patent US 5503785A from 02/06/1994] (Stratasys, 1994), thus opening the technique to the market for use and further development.

3.3 Derived Market Potential in Germany

Using the formula illustrated in Chapter 2.1.1 an estimation of the IMP is undertaken.

3.3.1 [N] Number of Consuming Units [number of potential buyers]:

“Development of an innovation is the process of putting a new idea in a form that is expected to meet the needs of an audience of potential adopters” (Rogers, 2003, p. 147). In a survey conducted TNS Emnid for Reichelt Elektronik, 69% of responders who did not own a 3D-pinter stated that they can see themselves using such a device in the future (TNS, Reichelt Elektronik 2015, p. 3).

The proposed device is a professional” device, thus located in a price range of more than $5.000 (Comp. Wohlers & Caffrey, 2014, p. 17). As professional users, this author broadly defines companies. As of 2015, there were 3.469.039 companies registered in Germany (Destatis, 2015). Within this figure, “company” is the smallest legally independent entity which is obliged to bookkeeping duties by law as, having to provide an annual balance sheet as well as freelancing workers (SABL, no date). As FFF is used for prototypes and finished goods as well as tools, concept models and haptic samples (Hiermenz, 2011, pp. 4-5), potential users must match at least the criteria of design, development and manufacturing/production of goods consisting of FFF available materials. Thus, the number of companies designing products, manufacturing tools, general plastic goods and other products incorporating parts that can be produced by FFF must be estimated.

Since potential buyers must have the investment capacity to invest into these machines, annual turnover times investment quota is used as an indicator during research. E.g.: In the engineering industry, the median investment quota was at 17.9% for 2015 (VDMA, 2015, p. 16), thus at an annual turnover of €250,000[4] allowing an investment of €44,750. Therefore, where filtering was available, only companies exceeding this turnover are included. Table two illustrates the company branch and the respective number of firms equaling or exceeding and annual turnover of 250.000 € for the WZ08-22 to 30 branches. In higher WZ08 number all companies are included as no filtering is available in the structure survey.

WZ 2008 Code	Industry Branch	Number of Companies					
		2011	2012	2013	2014	2015	2016
08-22.2	Manufacturers of Plastics Products	2779	2845	2873	2868	2865	2905
08-24.5	Foundries	430	426	415	416	423	416
08-25.73	Production of Tools (including Hand Tools)	882	866	866	859	855	882
08-28	Mechanical Engineering	5997	6112	6138	6136	6169	6203
08-29	Vehicle Construction	1337	1314	1319	1312	1326	1327
08-30	Vehicle Construction (other)	303	308	314	320	332	332
08-71.1	Engineering Consultants and Architects	23816	24467	25671	28049	29331	NA
08-74.10.1	Industrial-, Product-, and Fashion Design	1584	1755	1676	1665	1818	NA
	Total:	37128	38093	39272	41625	43119	
	Increase (+) Decrease (-) in %[5]		+2,6	+3,1%	+6,0	+3.6	

Table 2 - Estimated Size of Target Group Based on WZ2008 Codes
Source: Own compilation based on Destatis, 2017b & Destatis 2017b

As figures for the year 2016 are not available in all industries, data from 2015 is used. The Number of target companies thus is estimated at 43.000, rounded for full thousands.

3.3.2 [Δe] Increase of Equipment Rate

The adoption rate of any innovation will increase through diffusion: Any innovation, in this case 3DP, will undergo a process of diffusion with time (Rogers, 2003, p. 126). Diffusion itself is defined as "…the process by which an (1) innovation (2) is communicated through certain channels (3) over time (4) among the members of a social system (ibid., p. 11) while an innovation consists of the results of scientific research and development into a product that is ready to be adopted by potential users (ibid., p. 11). While the normal adoption of an innovation over time can be visualized as a bell curve, for the totaled number of adopters the curve tends to be S-shaped (ibid., p. 272). Adopters, in a normal scenario, can be categorized in 5 classes depending on their time of adoption: (1) innovators, consisting of 2.5% of total adopters, (2) early adopters at 13.5%, (3) early majority at 34%, (4) late majority at 34% and (5) the laggards at 16% (ibid., pp. 280-281). Figure four shows Rogers`s adoption curve with current adoption range of additive manufacturing highlighted in red.

[4] Available selection criteria in the Destatis Strukturerhebung

[5] Calculation: Δ N[%]=((100/(N-1)x(N))-100

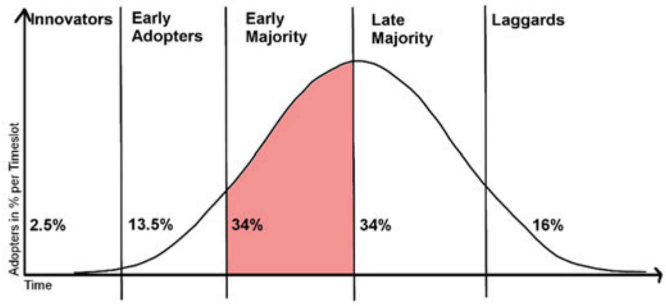

Figure 4 - Innovation Adoption Curve
Source: Rogers, 2003, p.281 (own adaption)

In 2011, the equipment rate for 3DP in general was estimated to be 8% of potential adopters (Wohlers & Caffrey, 2014, p. 115) and two years later, a continuous annual growth rate in turnover for these devices was expected at 20% until 2020. This figure has increased to 56% annually as of February 2016 (Krämer, 19.02.2016).

A study by PWC from March 2016 shows that 18% of Germans so far have used a 3DP device and 61% so far have not but are planning on doing so (PWC, 2016, p. 4). Across the branches of Automotive and aviation, plastics, engineering, electronics, pharma and medicine, consumer goods, energy, and logistics and transport, 37% of companies have experience with 3DP (Müller & Karevska, 2016, p. 2), with 53% of material demand originating in the plastics area (Ibid., p. 8). As this author could not identify further information in adoption rates and change thereof for the German market, three **assumptions** are made: **(3)**: The German consumer and the American consumer are homogeneous in their use of rapid manufacturing techniques, thus the markets for these devices are comparable. **(4)**: The adoption usage rate of consumers is identical with professional users since the answers in the PWC survey also included those professionally working with rapid manufacturing systems, and **(5)**: The adoption of rapid manufacturing technology follows Rogers “normal” scenario.

Considering the above-mentioned adoption rates, as well as the adoption rate of German consumers, rapid manufacturing currently is situated with the early majority of more than 16% and less than 50% of adoption. Using 18% for 2016 (PWC, 2016) and an increase of 56% annually (Krämer, 19.02.2016), the adoption rate to be reached in 2017 is 28.08%[6], which leads to the early majority of users (compare figure four) and an increase

[6] Calculation: 18%x1,56=28.08%

in equipment rate of 10.08%, however, this data does not discriminate between 3DP users in general and FFF users[7].

3.3.3 [Δn] net change of consuming units

In the period from 2011 to 2015, the number of companies in the target group has increased by an average of 3.8% annually[8] (data taken from table two).

3.3.4 [E] Equipment rate [units per buyer]

Since research aims at the nonuser gap for a first installment, one is used.

3.3.5 [V] Average lifespan

Depending on the grade of innovation of a new product, its market may not be clearly identifiable so that it can only be defined by using analog information of existing markets for products that cater to a similar target group and are used for comparable tasks (Tromsdorff & Steinhoff, 2013, p. 186). For Computerized Numerical Control [CNC] based milling machines (subtractive manufacturing) an average lifespan of seven years in the branch of engineering is expected (BMF, 2001), while the Deutsche Förderungsgemeinschaft expects a usage time of 96 months for rapid prototyping and rapid tooling machines when used for scientific purposes (DFG, 2012, p. 21). As no explicit information is found on FFF, the average of the lifespan from CNC machines and rapid tooling machines is used, thus 7.5 years.

3.3.6 [S] Substitution rate

The substitution rate is given as the percentage of existing devices being replaced by new types (Lambin et. al, 2007, p. 158). This value relates to the rate at which machines are discarded due to technical obsolescence or wear and tear and is proportional to the machine`s lifespan, e.g. its reciprocal value (Ibid., p. 157). With an average lifespan of 7.5 years, the substitution rate thus is estimated at 13.3%[9]

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[7] Author’s note

[8] Calculation: Δn=(2.6%+3.1%+6%+3.6%)/4=3.825%

[9]Calculation: 100 [%] / 7.5 [years] = 13,3%/year

3.3.7 [T] size of device population

Globally, 9832 professional rapid manufacturing systems were sold in 2013 (Wohlers & Caffrey, 2014, p. 117). Of these, 21% were sold on the European market. However, no trade figures are available specifying the number of systems sold on the German market[10]. To compensate, the **assumption** is made **(6)** that the number of rapid manufacturing devices sold correlates to the industrial size of a nation (Gross Domestic Product [GDP]) as compared to other member states of the European Union [EU]. As Germany is responsible for 21% of the EU's GDP (EuroStat, 2017), the corresponding number of devices is calculated as follows: T_{2014}=9832*0,21*0,21=434 sold in Germany in 2014.[11] Using a CAGR of 34.9% since 2014 (compare Wohlers & Caffrey, 2014, p. 109) as a constant growth rate, the current device population is estimated at T_{2017}=1058[12].

3.3.8 Estimation of Industry Market Potential

Thus, the total IMP, based on the data available and assumptions for missing data is calculated as: Q= [(43000*1.1008) + (1,038*1)] + [1058*(0.133+(1/7.5)] =47617[13], based on the year 2017, however, this value is estimated partially using non-FFF specific data, therefore including other AM process type machines.

This figure, after improvement thereof by survey results, is used to estimate the market usage gap in chapter 5.6.

4 Penetration Strategy

Based on a product's mission, thus defining its purpose and task to be fulfilled, market penetration can be seen as a company's attempts to increase its sales by either gaining on existing customers or finding a new market whose elements' mission requirement can be met by the product (Ansoff, 1958 (2009), p, 2). As a management concept, marketing can be understood as a concept that combines and organizes all of a company's

[10] Author`s note

[11] Calculation: 9832*0.21*0,21=433.59

[12] Calculation: 434*1,349*1,349*1,349

[13] $Q = [(n * \Delta e) + (\Delta N * e)] + [t * (s + \frac{1}{v})]$

activities towards reaching the market goals and requires a planned, coordinated and creative approach (Berekhoven et. al., 2009, p. 31).

4.1 Market Entry Order and Basics of Strategy

4.1.1 The Effect of Market Entry Order

While pioneers enter the market at the introduction phase of a product, followers do so in its growth or maturity phase (Specht & Zörgiebel, 1985, p. 162). Market share performance is calculated relative to the share of the first market entrant to the recent one. Empirical analysis of consumer goods has shown that the share of the nth entrant roughly "…equals 1 divided by the square root of its order of entry" (Robinson, et. al, 1994, p. 7), and even though the pioneers long term market share level will decrease over time, followers can expect to keep their share below the original pioneer (ibid., p. 19).

Later market entrants can benefit from a lower failure risk and decreased budget demand for product introduction since the first-mover already has created a basic demand (Urban et al., 1986, p. 645), while having to expect a market share permanently lower than the first mover's if the market is entered with a product having substitutable attributes (ibid., p. 655). A high market share can be reached by offering a uniquely differentiated product or a substitute at a lower price (ibid.). Furthermore, as markets mature, pioneers' lead in market share will shrink over time (Kalyanaram et. al., 1995, p. G216) and by introducing an improved product and extensively promoting it, part of the pioneer's advantage will be lost yielding market share for the follower (Urban et. al., 1986, p. 656). Any business, that either does not have a large budget for market entry or focuses on an overall low risk strategy should not pioneer a market (ibid., p. G219).

4.1.2 Generic Strategies

Sustainable competitiveness for businesses at the marketplace largely depends on the successful introduction of new products (Call, 1997, p. V), and only a small number of companies succeed in in providing a product desired by customers at the right place and right time (ibid., p. 258), while "new" does not necessarily mean new to the market but can also be so from a company's perspective, creating a company specific innovation that is already known on the market (Morner, 1997, p. 19).

Entry pioneers, thus the first companies "…to achieve a competitive scale of operations in a new market" (Robinson et. al, 1994, p. 18), tend to have a larger market share than followers as well as a broader portfolio of products (Robinson et. al, 1994, p. 18). Pioneers then are followed by entrants aiming at the market with product likeness and lower prices and by differentiation in providing decidedly different products (Carpenter & Nakamoto, 1989, p. 288). Establishing a product on a market with such entrenched competition creates a strategic problem (Carpenter & Nakamoto, 1990, p. 1268) and from a branding perspective, a later market entrant will not receive the same preference by customers as the pioneers without offering distinctive features in the product (Ibid., p. 1269). CARPENTER and NAKAMOTO suggest that later market entrants should focus on one of two types of strategy: (1) In case of a market pioneer with a strong competitive advantage (customers' association with the product) over the follower, a **product differentiation strategy** with a large marketing budget gains the highest in market share and profit by offsetting from the dominant market element (Carpenter & Nakamoto, 1990, pp. 1276-1277) and (2) with a challenger strategy in case of a market pioneer with low or no competitive advantage, aiming directly at the pioneers' market share with a high price and large marketing expenditure and low product distinction leads to optimal market share as the pioneering company lacks protection from competition (ibid., p. 1277).

The **"Me-Too" strategy** offers a second low differentiation strategy (Carpenter & Nakamoto, 1989 p. 1274), however if the pioneer and its brand is archetypical for the product, positioning close to him at a lower price can inadvertently lead to a strengthening of his market share and competitive position (Carpenter & Nakamoto, 1990, p. 290).

4.1.3 Competitive Strategies According to Porter

The goal of competitive strategies is to counter negative forces on the company, such as competition, and to yield a market position that can be held against competitors (Porter, 1980, p. 34). Porter defines three types of generic competitive strategies (1) cost leadership (2) differentiation and (3) focus (Porter, 1980, p. 35). **Overall cost leadership** demands a large relative market share, focuses on minimizing costs, from research and development up to sales and building products that can be easily fabricated. Furthermore, it requires a high up-front investment and aims at all possible customers to utilize economies of scale (Porter, 1980, pp. 35-36). Vulnerability of cost leadership arises through inflation that can change price advantage relative to a competitor, imitation by new market entrants producing at lower costs due to newer facilities, obsolescence of technology invested in, and failure so see trends and changes on the market because attention is solely placed on maintaining a low-cost structure (ibid., p. 45).

Differentiation strategy aims at offering a product or service that [analog to Nakamoto, 1990] [14] is "…perceived industrywide as being unique" (Porter, 1980, p. 38). Differentiation can be achieved by technology, service and brand image and protects against competitors due to customers' brand loyalty and following decreased price sensitivity (ibid., p. 37). Major risks to successful differentiation include a change in the need of customers, which equalizes the differentiating factors; increasing price differential between the differentiated product and substitutes can overcome brand loyalty and limit the gain perceived through the brand closeness to the original product (Porter, 1980, p.46). Just as cost leadership strategy, differentiation requires large resources and is primarily suitable for large companies (Wright, 2010 (1987), p. 2).

The **focus strategy** implies targeting a specific group at either lower cost or by serving the demands of this group more detailed, thus differentiating not on the complete market but on a more closely defined market target (Porter, 1980, p. 38-39). This can include developing products according to the needs of single buyers and placing products at the weak points of competitors` portfolio, hence protecting from more generalized substitutes and gaining relative competitive advantage (ibid.). A successful focus strategy is threatened by a competitors' aiming at more detailed submarkets within the segment, therefore focusing closer then oneself, a waning difference between the total market and its subgroup and a lowering of the cost differential between wide-aiming and narrow aiming competitors and thereby undoing the cost advantage previously gained by focusing (ibid., p. 46). This type of strategy is recommended for smaller businesses (Wright, 2010 (1987), p. 2)

4.2 Technology Orientated Strategies

Specht and Zörgiebel improve upon Porters' basic three strategy types with a focus on technological positioning by detailing on the timing of market entry, market reach and degree of individualization, conceptualizing eight strategy types (comp. Specht & Zörgiebel, 1985, pp. 162 ff.). Since this research aims at a specific market segment (see chapter 3.3.1), and companies already in the market were found (chapter 3.1) only the

[14] Author's Note

segment specific follower strategies are mentioned, numbered in accordance with the source:

1) Segment specific individualization as technological leader

This aims at generating competitive advantage by providing customers with individualized solutions (Specht & Zörgiebel, 1985, p. 163). While the cost focus is secondary, personal communications and direct sales dominate the marketing strategy with emphasis on a narrow product portfolio at high prices and high investments in product development are necessary to gain the market segment (ibid.). As the innovative scope lies in product based newness, risks include a high degree of design and development coupled with intense costs while being dependent on a small market segment (ibid.).

2) Segment specific individualization as technological follower

Aiming at gaining price advantage over competitors, this orientation is meant to solve explicit customer problems by applying existing knowledge and technology, realizing a low to medium price level by taking advantage of platform systems (Specht & Zörgiebel, 1985, p. 163). This orientation shares the segment dependency risk and envelopes a lacking reaction to industry changes due to the unavailability of in-depth technical knowledge (ibid., p. 164).

5) Segment specific standardization as technological leader

This orientation tries to generate competitive advantage by standardizing innovative technologies for selected market segments with the goal of introducing these products as the desirable standard solution with a medium to high price level (Specht & Zörgiebel, 1985, p. 165). While putting strong emphasis on research and development, thus investments therein, a narrow segment based technical knowledge suffices (ibid., p. 166). Risks develop by the strong likelihood of product-market-failure in the process of establishing the new standard and the market dependency is analog to other segment strategies (ibid., p. 166).

6) Segment specific standardization as technological follower

Gaining competitive advantage by directly selling proven and known technology and products at a low price level, this orientation requires a market where a large market share can be gathered at its growth- and maturity phase (Specht & Zörgiebel, 1985, p. 166). While the follower can avoid the pioneers’ mistakes and can build upon an existing market with available information, risks include a lack of technological know-how and a lack of flexible production processes (due to standardization and cost focus) as well as the difficulty to penetrate a market previously conditioned by a pioneer (ibid., pp. 166-168). Figure five illustrates the dimensions of Specht & Zörgiebels' segment specific technological follower strategies.

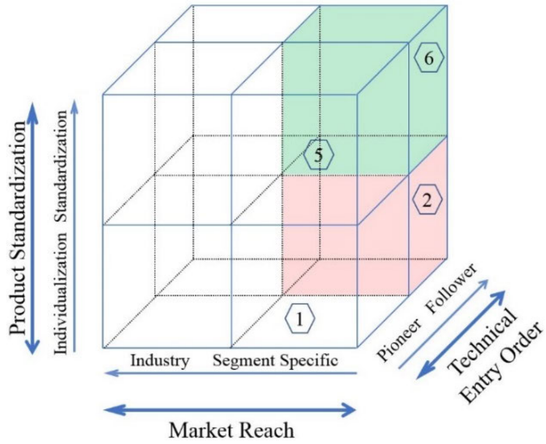


Figure 5 - Technology Orientated Strategic Options
Source: Specht & Zörgiebel 1988, p. 162, (original numbering, own adaption)

4.3 Market Entry Strategies for Young Technical Companies

RÜGGEBERG defines young technological companies [YTC] as firms that market a newly developed product with a high research and development expenditure or own patent, which incorporates an innovative product that is, at least in part, self-produced (Rüggeberg, 1997, p. 21). In an analysis of the market success rate of 140 YTCs, thus introducing the dimension of company age, he identifies six types of strategy (creative-international outpacer [I], laggards [II], cooperating outpacing pioneers [III], service-orientated market-synergetics [IV], dependable, good value individualizers [V] and innovative high-tech and high-price pioneers [VI]) (ibid., pp. 203-205). The two strategies with the highest success rate are discussed in more detail:

The second highest success rate offered the innovative high-tech high price pioneers (ibid., p. 206). This strategy is identified by a strong pioneering position on the market, offering new technological solutions as standard- as well as individualized products - and the strategy aims at an above average internationalization speed, seeking out cooperation for research and development and marketing. (ibid., p. 205). Based on their technical pioneering position, they benefit from a price premium (ibid.) with the product offering an above average technological advantage to customers, meanwhile incorporating a low obstacle to adoption by customers and so creating competitive advantage (Rüggeberg, 1997, pp. 214-215).

Highest in success rate was the creative-international outpacer strategy, which summarizes companies offering standardized products aiming at fast internationalization with lowest possible prices and unconventional marketing (ibid., p. 203). Outpacers address an above average technology-based competitive advantage which can contain a high obstacle to adoption by customers (ibid., p. 209). Despite being resource intensive, the outpacer strategy may be realized with low resources if a specialized market with low competition, strong growth and homogenous customer demand can be found (ibid., p. 2010).

4.4 Best Practice Example of Successful Market Penetration

By comparing two successful market entrants, their strategic and product focus is elaborated upon.

4.4.1 BigRep GmbH

Founded in 2014 in Berlin / Germany, BigRep introduced their large scale FFF device “BigRep One” in 2015 and shortly afterwards received funding from external investors and support from the Pro Fit Program of the “Europäische Fond für Regionale Entwicklung” for the development and sale of novel 3DP devices and materials (BigRep 2017c & Floemer, 16.03.2016). In 2017, the Klöckner Group got involved with BigRep GmbH and provided further funding, expecting an annual growth of 20% in the market segment (Klöckner & Co. SE, 21.04.2017). The company expands globally, having founded subsidiaries in the United States and Singapore, selling their devices via a network of resellers in North- and South America, Africa, Europe, Russia, Australia and China (BigRep 2017d). They communicate their portfolio for the niche of “large scale” and the broader “desktop” on trade shows, and online via their website and social media. Furthermore, the company offers device specific trainings, on-site and in-house introductory courses for the use of their AM devices, themed as “BigRep Academy”, as well as downloadable whitepapers and use cases (Big Rep 2017e).

4.4.2 Titan Robotics

The company was founded in Colorado in 2014 and introduced their large-scale Atlas range of FFF devices in 2015 (Peterson, 3.2.2016; Grunewald, 10.12.2015) and the larger Cronus in January of 2017 (Saunders, 12.01.2017). The price range for the Atlas printers starts at $24.000 and can be customized according to customers` requirements (Gooch, 10.12.2015), and the company puts emphasis on the high quality of their devices as well as their innovative approaches by utilizing multiple extrusion heads to decrease build times (Davies, 9.2.2017). Moreover, Titan Robotics offer a 3D printing service with their devices (Titan Robotics, 2016 & Titan Robotics, 2017).

The company had an estimated revenue of $500.000 in 2016 and is expecting a threefold increase in sales in 2017 (Baillie, 13.01.2017). They present their machines at domestic trade shows (Garret, 16.05.2017) and use social medial (twitter, Instagram, Facebook and YouTube) as well as their website to market the devices (Titan Robotics, 2016a)

4.4.3 Best Practice Summary

Table three summarizes the finding of the successful market entrants in the best practice example. While both companies use online and direct marketing channels, trade shows and social media, only BigRep GmbH offer additional services and trainings to their customers. While both offer customizable devices, Titan Robotics offers large scale devices only while BigRep GmbH’s portfolio includes desktop devices as well. These examples indicate that successful market entrants use segment specific orientation and put emphasis on technological development.

	Company	
Channels	BigRep GmbH	Titan Robotics
Website	+	+
Reseller	+	0
Subsidiaries	+	0
Trainings	+	0
Trade Shows	+	+
Social Media	+	+
Newsletter	+	0
Printing Service	+	+
Market Reach	segment "large scale"+” desk-top”	segment “large scale”
Market Geographic’s	Global	Domestic (USA)
Founded	2014	2014
Entry	2015 (BR One)	2015 (Atlas)
Customers	BMW, DB, Airbus	n.a.
Proposed Strategic Focus	segment specific individuali-zation as technological leader	product differentiation

Table 3 - Strategic Best Practice Summary of Successful Market Entrants

5 Target Group Classification and Market Usage Gap

This Chapter provides primary information in the form of a survey of potential users. The primary research deals with the underlying thesis that there is a viable market potential for large scale FFF-devices, in particular of a build size of 1000*1000*1000 mm and aims at identifying elements from the target group that have a high likelihood for FFF usage. Additionally, the survey is to generate primary data about the market potential of the specified FFF devices.

5.1.1 Formulation of Research Problem and Identification of Primary Research Need

This survey is to identify criteria that can be used to discern companies that utilize FFF or might do so and provide firmographic details. These will be used to classify the participants to identify the proposed market usage gap for large scale FFF devices.

In literature, information can be found regarding the general adoption of AM technologies (comp. Wohlers, 2010 & Wohlers & Caffrey, 2014), as well as technical applications of FFF and its technical properties (Comp. Gibson et. al., 2015, pp. 160-165 & Gebhardt, 2013) and economic impact (comp. Weller et. al., 2015). Even though users of this technique and application can easily be found, this author could not find literature broaching the issue on a more specific scale, e.g. what business branch and size decides for what devices. Thus, the goal of this research is to find factors that can be used to classify companies based on their AM demand. Furthermore, the IMP calculated Chapter 3.3.8, and the actual adoption rate are estimates only. The actual process type-specific (FFF) adoption rate and the size of the device population is needed to “refine” the IMP and estimate the size of the market usage gap (comp. Chapter 2.1.1 & 3.2.2). Also, as competitor analysis has shown, current manufacturers not only offer the devices themselves, but service and personnel training (comp Chapter 4.3). For a strategic recommendation, an attempt to estimate the importance of services offered is made.

This leads to the following research questions:

1) What branch does the participating company belong to?
    a. Are there differences in the FFF / FDM usage by industry?
2) Is the company using 3DP, if not, are they planning to do so?

3) What system type of 3DP is in use and how many of each?
    a. What is the market share of FFF / FDM in the target group?
4) For the non-users, what process type and build size are they interested in?
5) What size of device are the users utilizing (build volume)?
6) How important are various device properties?
7) How important are after sale services and training for the customers?

5.1.2 Definition of the Population of Statistical Universe

Who is to be part of the statistical universe depends on the goal of the research and two questions have to be answered [1] who is to be asked / observed? and [2] how large is the total statistical universe? (Berekhoven et. al, 2009, p. 43). To be part of the statistical universe, companies must fulfill two requirements, firstly, they must be German companies (active on the German market), secondly, they must be part of a branch indicated in chapter 3.2.2.1 As the size of the target group has been previously defined, the population of the statistical universe is estimated at 43.000(See table two for details). From this statistical universe, a sample of 750 companies is contacted.

5.1.3 Choice of Survey Method

To create information, either previously gathered data can be analyzed [secondary research], or own data must be collected [primary research] (Cudic, 2011, p. 107). If no secondary data is available, primary research must be undertaken by either conducting surveys, asking members of the statistical universe personally, or observation (Cudic, 2011, p. 107, also Berekhoven et. al, 2009, p. 43). As the survey aims at total statistical universe of 43.000 companies, observation was not possible with resources available for this research, therefore a survey was chosen. Two general methods of surveying are the questionnaire with pen and paper and the electronic questionnaire (Döring & Bortz, 2016, p. 417). While the former is distributed by mail, the latter may be spread by data media or online (ibid.). Online surveys offer the advantages over face to face methods that participants can answer the questions at a time of their convenience, at their own speed and also tend to answer questions more critically (Berekhoven et. al, 2009, p. 108).

Since either observing or interviewing members from 750 companies would create an insurmountable obstacle within the scope of this thesis, the online questionnaire method is chosen.

5.1.4 Operationalization of Research Questions and Coding Plan

The following table illustrates the research questions, and detailed operationalization of possible values:

Research Questions	**Operationalization**	**Questionnaire Items with sub-items in square brackets and coding in round brackets**
1) What branch does the participating company belong to?	Closed question, single choice with added text field	Item 17: Molds manufacturing [17a], manufacturing of plastic products [17b], industrial design [17c], vehicle production [17d], engineering [17e], modelling [17f], product design [17g], prototyping [17h], tools construction [17], no information [17j], free text [17k]
2) Is the company using 3DP, if not, are they planning to do so?	Binary questions, yes or no	Item 1: Are / your company currently using additive manufacturing (3D-printing)? ➔ yes= ”current users”
		Item 2: In the past 12 months, have you considered the use of 3D-printers in your company? ➔ yes= ”considered users”
		Item 3: Can you see your company using 3DP? ➔ yes= ”poss ble users”
3) What system type of 3DP is in use and how many of each?	Device type: Closed question, multiple choice with added text field	Item 4: Binder Jetting [4a], FDM [4b], Polyjet Modeling [4c], SLS [4d], SLM, [4e], SLA [4f] other (free text) [4g]
	Number of devices: closed question with multiple text fields	Item 5: Number of each type, analog to Item 4
4) For the non-users, what process type and build size are they interested in?	Device type: Closed question, multiple choice with added text field	Item 7: Identical with Item 4 and subitems
	Build Size: single choice	Item 8: Identical with Item 6 and subitems
5) What size of device are the users utilizing (build volume)?	Build Size: single choice with additional text field	For current users: Item 6: Five classes of build volume 500x500x500 or smaller [6a], up to 800x800x800 [6b], up to 900x900x900 [6c], up to 1000x1000x1000 [6d], larger [6e], other (free text) [6f]
		For considered users: Item 8 and analog [8a]-[8f]
		For possible users: Item 9 and analog [9a]-[9g]
6) How important are various device properties?	Rating scale 0-100 points from “unimportant” to “absolutely necessary	For current users: Item 11: Build speed [11a], build space [11b], build detail [11c], simultaneous multi-material ability [11d]
		For considered users: Item 13 and analog [13a]-[13d]
		For possible users: Item 15 and analog [15a]-[15d]
7) How important are after sale services and training for the customers?	Rating scale 0-100 points from “unimportant” to “absolutely necessary”	For users: Item 12: Frequent updates for the 3d-printer’s firmware (operating system) [12a], frequent news on technical improvements and upgrades to the device [12b], offered maintenance service [12c], Personnel training for the use and set up of the printer [12d], trainings and seminars for optimization of printing models ("printing optimized development") [12e], Offered installation and setup service [12f]
Company data	Free text answer	Item 18: Number of technical employees Item 19: Total number of employees
	Classed answer, single choice: 9 classes plus “no information” (based on Destatis, 2015, p. 13)	Item 20; Annual turnover in €: <250.000; 250.000<500.000; 500.000<1.000.000; 1.000.000<2.000.000; 2.000.000<5.000.000; 5.000.000<10.000.000; 10.000.000<25.000.000.; 25.000.000<1000.000.000.; larger; “no information”

Table 4 - Research Questions Operationalization and Coding Plan

5.1.5 Questionnaire Design

The questionnaire is found in the appendix. For details on its function please refer to appendix IV “Survey Questionnaire Flowchart”.

5.1.5.1 Pretest and Changes

Prior to inviting the participants, the survey was send to four people, two of those being engineers and two with a management background without 3DP experience /knowledge and their understanding of the survey questions discussed via telephone. Changes were recommended and adopted as follows:

- Items 4, 7 & 9: Links to online articles added to offer an explanation of the device types if needed
- Items 11, 12, 13, 14, 15, & 16: Original five-point rating scale changed to 100 points to allow for a “better resolution” of possible answers

5.2 Survey Process

By utilizing an online service, members of the target groups whose contacts have been previously researched, were contacted via email on July 30 and July 31st, 2017 and invited to participate in an online survey (appendix no. III “Survey Invitation Email”). On August 1st, 2017, a reminder email was send to the sample group, aiming at an increased response rate and clarification of the limited survey duration (appendix no. IV “Survey Invitation Reminder Email). and clarifying the limited timeframe of the survey of August 8 h, 2017. After the given maximum response time, the generated data is analyzed using IBM SPSS Statistics.

5.3 Survey Results

5.3.1 Survey Response Population

A sample is representative if the distribution of all its relevant characteristic match those of the total statistical population and / or their makeup allows to draw conclusions valid for the total statistical population (Berekhoven et. al, 2009, p. 45). Table five illustrates the industry composition of the total statistical universe in comparison to the sample response population. Since the relative makeup of both groups is not identical, the survey results are not representative. The table gives the statistical population and sample responders and representation status with “=” for “representative, “+” for overrepresented and “-“ for underrepresented.

WZ 2008	Industry Branch	Number of Companies				
		Statistical	%	Sample	%	Representation
08-22.2	Manufacturers of Plastics Products	2865	6,6	5	4.5	-
08-24.5	Foundries	423	1.0	2	1.8	+
08-25.73	Production of Tools (including Hand Tools)	855	2.0	13	11.8	+
08-28	Mechanical Engineering	6203	14.4	7	6.4	-
08-29	Vehicle Construction	1326	3.1	3	2.7	-
08-30	Vehicle Construction (other)	332	0.8/	0	0	-
08-71.1	Engineering Consultants and Architects	29331	68,0	1	0.9	-
08-74.10.1	Industrial-, Product-, and Fashion Design	1818	4.2	54	49.1	-
n.a.	No branch given	0	0	25	22.7	n.a.
	Total:	**43119**	**100**	**110**	**100**	

Table 5 - Statistical Population and Response
Source: Own data, based on Berekhoven et. al., 2009, p. 48

5.3.2 General Usage Incidence

The results show, that of 110 participants, 61 (55.5%) currently use AM in general, 17 (15.5%) have considered the use of AM and 15 (13.6%) are possible users while 17 (15.5%) did not answer Item one. A total of 36 participants (32.7) use FFF, while nine (8.2%) have considered its use and two (1.8%) see its use as possible. Of these FFF users, four (3.6%) are using a device with a build size of 1000x1000x1000 mm or larger and two (1.8%) have considered utilizing this device size[15].

5.3.3 Fused Filament Fabrication Usage Incidence by Industry

Table six illustrates the FFF usage incidence in “current users” by industry[16] and the total number of devices used. Industries without usage cases are omitted. The highest relative FFF usage incidence is found in the Industrial-, Product-, and Fashion Design segment followed by Tools Production and Mechanical Engineering.

WZ 2008	Industry Branch	Number of Companies			
		Users	Devices	%	Users [%] in
08-22.2	Manufacturers of Plastics Products	1	2	4.5	20%
08-25.73	Production of Tools (including Hand Tools)	3	7	11.8	53.8%
08-28	Mechanical Engineering	3	3	6.4	42.9%
08-29	Vehicle Construction	2	1	2.7	33.3%
08-74.10.1	Industrial-, Product-, and Fashion Design	25	40	49.1	74.1%
n.a.	No branch given	2	25	22.7	8.0%.
	Total:	**36**	**78**	**100**	

Table 6 - Usage Incidence of Fused Filament Fabrication by Industry

[15] Filter: [Item4bFDM = "FDM" & Buildsizeclass >= 4], N=6

[16] Filter: [UserType = 1 & Item4bFDM = "FDM"]

5.3.4 Importance of Device Properties by User Type

Figure six illustrates the average point value of the importance of device properties by the user groups ”current users“, “considered users” and “possible users” of additive manufacturing. While, apart from of build speed, possible users value device properties generally lower than considered-, and current users, build detail level has the highest score in all user groups followed by build space. Least importance was given to the simultaneous multi-material capability. Through all user types build detail is the most important property, followed by build space and build speed ranking third.

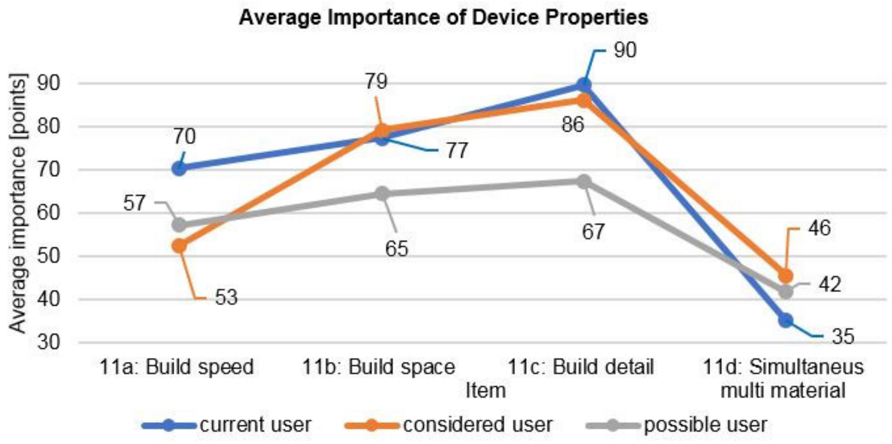


Figure 6 - Average Importance of Device Properties

5.3.5 Importance of Services by User Type

For “current users”, maintenance service is the most important aspect of services, followed by frequent firmware updates and personnel training for printer setup. Installation of the device and construction seminars score lower than in the other user groups. In the non-user groups, installation, and training variables are valued as more important than in the user-group. For considered users, highest importance of service aspects is found in personnel training, followed by installation of the device and construction seminars. In the group of possible users, “Frequent news updates on improvements” has the lowest importance value of all these items. An overview of the results is given in figure seven.

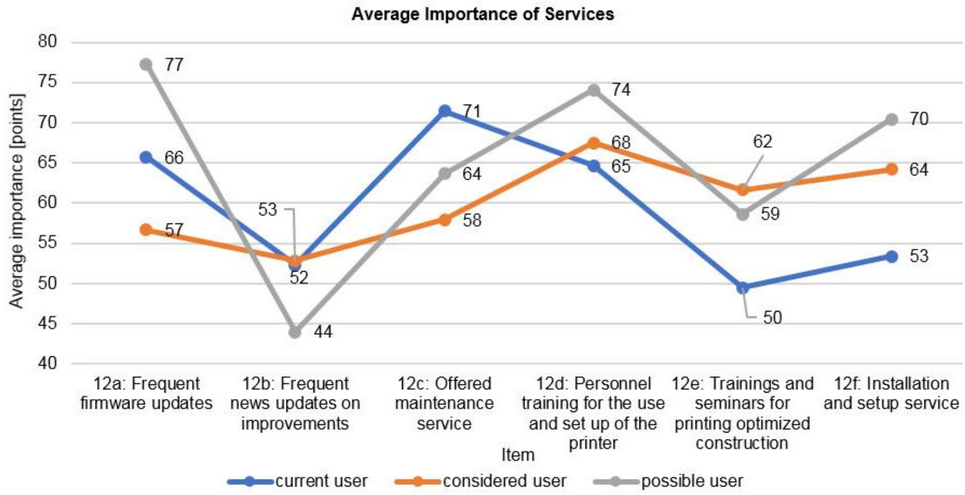


Figure 7 - Average Importance of Services

5.4 Classification of Target Group

Classification analysis is used to separate a statistical population into different segments to then identify what element belongs to which segment (Brühl, 2014, p. 695). A decision tree can be used to classify data, either explorative or validating, for a dependent variable based on independent variables and is utilized to segment data and to predict future events [e.g. use of AM][17] (IBM, n.d., p. 1). The sub-populations of the statistical universe are ranked depending on the degree of influence their dependent variables have on the independent one (Bühl, 2014, p. 695) while the tree structure visualizes each variables' influence, omitting those that have no influence (ibid.). As statistical method "Exhaustive CHAID is used. As significant error probability, a P-value of 0.05 is used (comp. Brühl, 2014, p. 177).

Underlying the classification are three hypotheses:

H1: The general users of additive manufacturing can be classified with the available, collected company information, thus company data can be utilized as a predictor for usage incidence utilizing a decision tree classification (Chapter 5.4.1).

H2: The users of FDM / FFF technique can be identified with the available information and used for prognosis of potential customers using a decision tree classification (Chapter 5.4.2).

[17] Author's note

H3: Machine build sizes that users utilize and that non-users are interested in can be identified by available company data and used for prognosis of potential customers using a decision tree classification (Chapter 5.4.3).

5.4.1 Classification of General Additive Manufacturing Users

For this analysis, item 1 (current use of 3DP) is used as dependent variable and as independent variables Item 17 (industry branch), Item 18 (number of employees), item 19 (number of technical employees) and Item 20 (annual turnover) are used.

The model excludes all independent variables (model summary: Table 14, p. XVI in the appendix). As figure eight shows, the tree consists of node zero only, not allowing for a classification of user types by either of the independent variables. Therefore, hypothesis one is rejected.

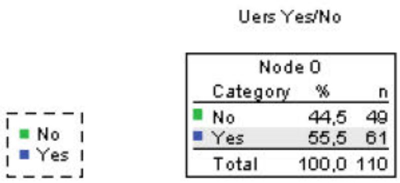


Figure 8 - Classification Tree for General Additive Manufacturing Users

Classification of General Additive Manufacturing Users

	Predicted		
Observed	No	Yes	Percent Correct
No	0	49	,0%
Yes	0	61	100,0%
Overall Percentage	,0%	100,0%	55,5%

Growing Method: EXHAUSTIVE CHAID
Dependent Variable: User Yes/No

Table 7 - Classification of General Additive Manufacturing Users

5.4.2 Classification of Fused Filament Fabrication Users

As independent variable item 4b (used device type FDM) is used. Independent items are analog to 5.4.1. As focus is on elements where usage data is available, cases without usage data are excluded[18], leaving 96 cases for the analysis with user types "current", "planned", and possible".

The model includes the variables Industry branch and user type, omitting the number of (technical) employees and annual turnover, creating a tree with depth of five branches and at a total of five nodes (model summary: Table 15, p. XVI in the appendix). The risk estimate shows that the model explains in total 22.6% of FFF usage cases incorrectly, thus 77.4% correctly (Comp. Bühl, 2014, p. 705). The non-users are predicted with an accuracy of 65.2% and the FFF / FDM users with 89.4% (see table eight).

Classification of Fused Filament Fabrication Users

	Predicted		
Observed	Non-FDM	FDM	Percent Correct
Non FDM	30	16	65,2%
FDM use / interest	5	42	89,4%
Overall Percentage	37,6%	62,4%	77,4%

Table 8 - Classification Table of Fused Filament Fabrication Users

The tree diagram (figure nine) shows that the variable with the highest predictor value is Item 17 "Industry branch" which branches with a very significant p-value (comp. Bühl, 2014, p. 177) of 0.003. On the second tree level, node 1 containing the branches vehicle construction, manufacturer of plastic tools, mechanical engineering, production of tools, and industrial-, product-, and fashion design hast the highest percentage of FFF users. On the third tree level, node 2 is separated by user type into current-, and considered users in node 3 and possible users in node 4 at highly significant P-value of 0.001 (comp. Bühl, 2014, p. 177).

[18] Filter: UserType = 1

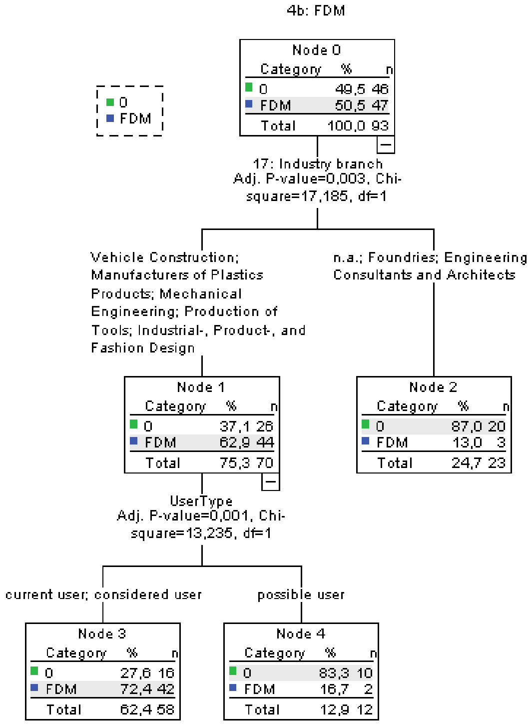


Figure 9 - Classification Tree of Fused Filament Fabrication Users

Based on the available data, for companies belonging to the industries in node one, there is a 89.4% correct prediction that there is a current usage or considered/possible usage incidence of 72.4% in that subgroup. In contrast, the companies in node two there is a 89.4% correct prediction that 13% will be current or considered/possible users of FFF. Considering the results of the Tree Analysis, hypothesis two is accepted.

5.4.3 Classification of Large Scale Fused Filament Fabrication Users

Classification of large build size users is predicted using “Build Size Class” as dependent variable and “annual turnover”, “Industry branch”, “number of technical employees” and “number of employees” as independent variable. The independent variable included in the model is “Industry branch”, which splits node 0 with a very significant p-value of 0.008 (Comp. Bühl, 2014, p. 177). The

While the model in total explains 36,4% of build size class incorrectly, thus 63.6% correctly, a relevant prognosis at 92.6% correct is given solely for the build size class

“500x500x500 or smaller” and the correctness of prognosis for “1000x1000x1000” is zero percent (classification table: Table 16, p. XVII in the appendix).

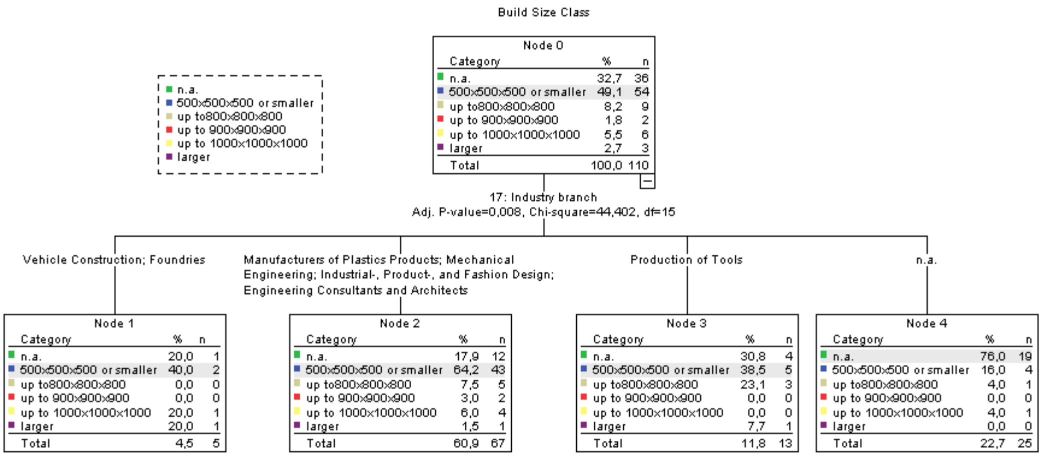


Figure 10 - Classification Tree of Large Scale Fused Filament Fabrication Users

As this model does not allow for a prediction of large scale use, hypothesis three is rejected.

5.5 Key Findings

The adoption rate of AM in the sample is at 55.5% (usage incidence), exceeding the previously estimate rate of 28.08% (see chapter 3.3.2) Users and non-users of AM technology value device properties, while all user groups see build detail as most important and the simultaneous use of different materials [multiple print heads] as least important. Regarding services offered by the manufacturer, the importance of trainings and introductory courses generally decreases with usage involvement (decrease from current- to considered- to possible users). Difference in the usage rate of FFF by industry are found in the sample, varying from 74.1% in the design branch to 20% for manufacturers of plastic products. Machines of build sizes ranging from 500x500x500 mm or smaller up to 1000x1000x1000 or large are found to be in use, while generally, the number of current-, planned-, and possible users decrease with increasing build size of the machines (figure 13, p. XV in the appendix).

5.6 Adjustment of Industry Market Potential and Market Usage Gap estimate

As chapter 3.4.8 shows, the IMP is estimated at 43,000 units, however this figure lacks information on the actual adoption of large scale FFF devices. In the following, this estimation is improved using survey data.

While the overall adoption rate of 3DP is found to be 55.5%, the actual adoption rate of FFF is only 59% of the AM users, thus 32.7% in the target group (comp. 5.3.2). Moreover, as shown in chapter 5.3.2, one tenth of FFF users (3.6% of survey response group) utilize a large build size equaling or exceeding 1000x1000x1000 mm while another 1.8% consider its use.

The IMP previously estimated is 47617 devices. Factoring this usage incidence and planned usage for large scale devices into the IMP creates a multiplication factor of 5.4%, thus the IMP estimation for large scale fused filament fabrication devices is corrected (improved) to 2571 units at this time.

Based on this figure, and considering that 3.6% of the 43.000 companies in the target group use large scale devices, 1548 devices should be in use in the target group, assuming an even distribution based on the non-representative survey, this opens an estimated market usage gap of currently 1023 units, not counting for an increased adoption in the future.

6 Conclusion

6.1 Summary and Strategic Implications

The market for AM in general, and for FFF is growing, in regard to the number of manufacturers as well as to the technology's adoption by customers. Multiple companies offering devices in the targeted build size are found to be on the market.

The number of companies in the defined target group is quantified. Furthermore, devices of large build sizes are found to be in use as well as in use consideration by members of that market segment, showing a demand for large build sizes and, despite this demand being lower than for smaller machines, a market usage gap has been identified, thus determining the existence of demand for large build size FFF devices. Also, the survey shows the overall adoption of AM in the target group being higher than the total adoption listed in secondary sources, hinting at the importance of the technology for this group.

Research shows that there is a tendency to stay below the pioneers in means of market share. Strategies for a non-pioneering entry / penetration are found to focus on either an industry niche of the market, unique technological positioning or on a price differentiation while for YTCs either technological pioneering or fast internationalization are most successful. If the market is to be penetrated, this cannot be done in a pioneering position, as prior entrants already are established. Considering the importance given by users and non-users in the survey towards service and device properties, strategically it is recommended to focus on the build detail and build space of the device while elaborating on services that can be provided with and after purchase of the device, chiefly on personnel training, since those are most important to non-users.

Even though the classification analysis could not identify company specific factors for the use of large scale FFF devices, since an unfulfilled market potential is identified, it is recommended to penetrate the market focusing on a service oriented differentiation strategy, aiming at the industries with the highest relative usage incidences, attempting to outpace the pioneering competitors on that specific target market with the technological scope of build space and detail level, utilizing segment specific individualization in the service aspect..

6.2 Critical Acclaim

Market information on the specific adoption of FFF, especially with a focus on the German market, was not found during research for this thesis, and the amount of scientific literature dealing with AM in a business perspective is marginal. It is at this point that this thesis enters a new realm.

However, the results of this research can only be judged on a limited scope since firstly the survey was non-representative and the projected classification of large scale FFF users could not be undertake due to the small size of the sample and secondly, part of this work is based on assumptions where information needed to further the course of investigation was not available, e.g. precise sales figures for this device type.

Nonetheless, this work can be used as a framework to be updated with more accurate information for further studies and the importance values found in the survey can be used as a guideline for technological development of FFF devices, e.g. what device properties of the machines toto emphasize on.

6.3 Outlook

As this work is, in part, based on six assumptions (table 18, p. XVII in the appendix), each of these can be basis for further research to improve the understanding of the FFF market in Germany and how and why customers adopt this technology. Especially the professional users attitude towards FFF, questions as to why this process type is adopted in favor over others, offer a field of study that could not be included into this work, also, the correlation of a nations GDP and the number of devices sold (assumption six) offer chance for research and debate.

To allow for an improved company oriented prediction of FFF use, therefore specific targeting of potential customers, a broader, more refined survey of the target group is recommended and may yield more dependable data to allow for a specific contacting of potential users / customers. The same holds true for the current size of the device population and the estimated usage gap.

IV List of Reference

[Ansoff, 1958 (2009)]
Ansoff, Igor H.: "A Model for Diversification", Source Management Science 4(4) (1958), pp, 392-414, in "Corporate Strategy Volume 2 - Diversification and Growth", Krug, Jeffrey A. (ed.), Sagle Publishing limited, 2009

[Astor et. al., 2013]
Astor, Michael; Glöckner, Ulf; Klose, Georg; Plume, Anna-Marleen; Scheidenbach, Tina; von Lukas, Uwe; Bechthold, Ingrid; Ruth, Thomas; Jarowinsky, Michael; Bartels, Hans-Jürgen: "Abschlussbericht Marktperspektiven von 3D in industriellen Anwendungen", Frauenhofer IGD, MC, Prognos, 2014
https://www.igd.fraunhofer.de/sites/default/files/3D_Maerkte_Prognos_IGD_MC.pdf
Accessed: 12.07.2017

[Baillie, 13.01.2017]
Ballie, Amber: "Ten Companies to watch" The Colorado Springs Business Journal, 13.01.2017
http://www.csbj.com/2017/01/13/ten-companies-watch/
Accessed: 05.08.2017

[Berekhoven et. al., 2009]
Berekhoven, Ludwig; Eckert, Werner; Ellenrieder, Werner: "Marktforschung - Methodische Grundlagen und praktische Anwendung", 12th edition, GWV Fachverlag GmbH, Wiesbaden, 2009

[Bergen & Peteraf, 2002]
Bergen, Mark; Peteraf, Margaret A.: ”Competitor Identification and Competitor Analysis: A Broad-Based Managerial Approach”, Journal of Managerial and Decision Economics, 23 (2002), pp. 157-169

[BigRep, 2017a]
BigRep GmbH: "bigrep One - Der 3D-Drucker XXL für professionelle und industrielle Anwendung", BigRep GmbH, 2017
https://bigrep.com/de/bigrep-one/
Accessed: 28.07.2017

[BigRep, 2017b]
BigRep GmbH: "bigrep Studio - Grossformat 3D-Drucker mit Geschwindigkeit und Präzision", BigRep GmbH, 2017
https://bigrep.com/de/bigrep-studio/
Accessed: 28.07.2017

[BigRep, 2017c]
BigRep GmbH: "Homepage", BigRep GmbH, 2017
www.bigrep.com
Accessed: 05.08.2017

[BigRep, 2017d]
BigRep GmbH: "International Resellers"; BigRep GmbH, 2017
https://bigrep.com/contact/reseller/
Accessed: 05.08.2017

[BigRep, 2017e]
BigRep GmbH: "bigrep ACADEMY", BigRep GmbH, 2017
https://bigrep.com/academy/
Accessed: 05.08.2017

[BMF, 2001]
Bundesministerium der Finanzen [BMF]: "AfA-Tabelle für den Wirtschaftszweig "Maschinenbau"", Bundesministerium der Finanzen, 6.12.2001
http://www.bundesfinanzministerium.de/Content/DE/Standardartikel/Themen/Steuern/Weitere_Steuerthemen/Betriebspruefung/AfA-Tabellen/2001-12-06-afa-108.pdf?__blob=publicationFile&v=1
Accessed: 28.07.2017

[Bühl, 2014]
Bühl, Achim: "SPSS 22 - Einführung in die moderne Datenanalyse", 14th. Edition, Pearson Deutschland GmbH, Hallbergmoos, 2014

[Builder 3D, 2017]
Builder 3D Printers B.V.: "Meet the Builder Extreme 1000 & 2000", Builder 3D Printers B.V., 2017
http://builder3dprinters.com/wp-content/uploads/2017/07/Builder-Extreme-1000-2000-Flyer.pdf
Accessed: 13.07.2017

[Call, 1997]
Call, Guido: "Entstehung und Markteinführung von Produktneuheiten - Entwicklung eines prozeßintegrierten Konzepts", in Schriftenreihe Unternehmensführung und Marketing, Bd. 33, Gabler, 1997

[Carpenter & Nakamoto, 1989]
Carpenter, Gregory S.; Nakamoto, Kent: "Consumer Preference Formation and Pioneering Advantage" in Journal of Marketing Research, Vol. 26, No. 3 (August 1989), 1989, pp. 285-298
http://www.jstor.org/stable/3172901
Accessed: 16.07.2017

[Carpenter & Nakamoto, 1990]
Carpenter, Gregory S.; Nakamoto, Kent: "Competitive Strategies for Late Entry into a Market with Dominant Brand" in Management Science, Volume 36, Issue 10 (Oct. 1990), pp. 1268-1278
https://www.researchgate.net/publication/227446143_Competitive_Strategies_for_Late_Entry_into_a_Market_with_a_Dominant_Brand
Accessed: 17.07.2017

[Cudic, 2011]
Cudic, Jasna: "Produkthaltbarkeit im Strategischen Marketing - Eine empirische Analyse", Josef Eul Verlag, Köln, 2011

[D'Aveni, 2015]
D'Aveni, Richard: "The 3-D Printing Revolution", Harvard Business Review, 2015
https://hbr.org/2015/05/the-3-d-printing-revolution
Accessed: 27.07.2017

[Davies, 9.01.2017]
Davies, Sam: "Titan Robotics launch The Cronus 3D printer with five print heads", Rapid News Publication Ltd., 9.01.2017
http://www.tctmagazine.com/3d-printing-at-ces/titan-robotics-launch-the-cronus-3d-printer-five-print-heads/
Accessed: 03.08.2017

[Destatis, 2015]
Statistisches Bundesamt: "Finanzen und Steuern - Umsatzsteuerstatistik (Vornameldungen) 2015", Fachserie 14, Reihe 8.1, Statistisches Bundesamt (Destatis), 2015
https://www.destatis.de/DE/Publikationen/Thematisch/FinanzenSteuern/Steuern/Umsatzsteuer/Umsatzsteuer2140810157004.pdf?__blob=publicationFile
Accessed: 23.07.2017

[Destatis, 2017a]
Statistisches Bundesamt: "Strukturerhebung im Dienstleistungsbereich (WZ2008 2-4-Steller Hierachie), Statistisches Bundesamt, 2017
https://www-genesis.destatis.de/genesis/online?__site=
Accessed: 19.07.2017

[Destatis, 2017b]
Statistisches Bundesamt: "Jahresbericht für Betriebe im Verarb. Gewerbe Deutschland (WZ2008 2-4-Steller Hierachie)", Statistisches Bundesamt, 2017
https://www-genesis.destatis.de/genesis/online?__site=
Accessed: 19.07.2017

[DFG, 2012]
DFG-Geräteverzeichnis und Nutzungsdauer in Montane 2012, Deutsche Fördeungsgemeinschaft, 2012
http://www.uni-kiel.de/verw/zv/abteilung4/sg415/download/dfgliste2012
Accessed: 27.07.2017

[Döring & Bortz, 2016]
Döring, Nicola; Bortz, Döring: "Forschungsmethoden und Evaluation", 5th edition, Springer Verlag Berlin Heidelberg, 2016

[Eurostat, 2017]
Eurostat: "BIP und Hauptkomponenten", Eurostat, 13.7.2017
http://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do
Accessed: 13.07.2017

[Floemer, 16.3.2016]
Floemer, Andreas: "Möbel aus dem 3D-Drucker: Warum der 50.000-Euro-Riese BigRep One v3 sogar die Kanzlerin begeistert"; yeebase media GmbH, 16.3.2017
http://t3n.de/news/bigrep-v3-3d-drucker-ganze-689676/
Accessed: 05.08.2017

[Garret, 16.05.2017]
Garret, Maddie: "Titan's Faster 3D Printing Highlight of Rapid 2017", Titan Robotics, 16.05.2017
http://www.titan3drobotics.com/tag/trade-show/
Date Accessed: 08.05.2017

[Gartner 2017]
Gartner Inc.: “Compound Annual Growth Rate (CAGR)”
http://www.gartner.com/it-glossary/cagr-compound-annual-growth-rate
Accessed: 28.08.2017

[Gebhardt, 2013]
Gebhardt, Andreas: ”Generative Fertigungsverfahren – Additive Manufacturing und 3D Drucken für Prototyping – Tooling – Produktion” 4th. Edition, Carl Hanser Verlag, Munich, 2013

[Gibson et. al, 2015]
Gibson, Ian; Rosen, David; Stucker, Brent: ”Additive Manufacturing Technologies – 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing”, 2nd edition, Springer Science+Business Media, New Nork, NY, 2015

[Gooch, 10.12.2015]
Gooch, Jamie: "Company Profile: Titan Robotics", Peerless Media, LLC, 10.12.2015
http://www.rapidreadytech.com/2015/12/company-profile-titan-robotics/
Accessed: 03.08.2017

[Grunewald, 10.12.2015]
Grunewald, Scott J.: "Titan Robotics' Large Format Atlas 3d Printer Just Got Even Larger Formater: Introducing the Atlas 2.0", 3DR Holdings, LLC,10.12.2015
https://3dprint.com/110524/titan-robotics-atlas-2-0/
Accessed: 03.08.2017

[Hiemenz, 2011]
Hiemenz, Joe: ”3D Printing with FDM – How It Works”, Stratasys Inc, 2011
https://abm-website-assets.s3.amazonaws.com/mdtmag.com/s3fs-public/stratasys.pdf
Accessed: 27.07.2017

[IBM, n.d.]
IBM Corporation: "IBM SPSS Decision Trees 22", IBM Corporation, n.d.
ftp://public.dhe.ibm.com/software/analytics/spss/documentation/statistics/22.0/de/client/Manuals/IBM_SPSS_Decision_Trees.pdf
Accessed: 19.08.2017

[Kalyanaram et. al., 1995]
Kalyanaram, Gurumurthy; Robison, William T.; Urban, Glen L.: "Order of Market Entry: Established Empirical Generalizations, Emerging Empirical Generalizations, and Future Research" in Marketing Science, Vol. 14, No. 3, 1995, pp. 212-221

[Klöckner & Co, 21.04.2017]
Klöckner & Co SE: "Klöckner & Co beteiligt sich an Technologie-Start-up BigRep"; Press Release, Klöckner & Co. SE, 21.04.2017
http://www.kloeckner.com/de/pdf/klockner-co-beteiligt-sich-an-technologie-start-up-bigrep.pdf
Accessed: 05.08.2017

[Krämer, 19.02.2016]
Krämer, Andreas: "Marktforscher rechnen weiter mit rasantem Wachstum im Markt für 3D-Drucker bis 2020", Marcel Thum & Christoph Mann GbR JONGO Webagentur, Hildesheim, 19.02.2016
https://www.3d-grenzenlos.de/magazin/marktforschung/marktentwicklung-3d-drucker-bis-2020-27159433/
Accessed: 18.07.2017

[Lambin & Schuiling, 2012]
Lambin, Jean-Jacques; Schuiling, Isabelle: "Market-Driven Management - Strategic and Operational Marketing" 3rd. Edition, Palgrave Macmillan, Macmillan Publishers Limited, Basingstoke, 2012

[Lambin et. al., 2007]
Lambin, Jean-Jacques; Chumpitaz, Ruben; Schuiling, Isabelle: "Market-Driven Management Strategic and Operational Marketing"; Palgrave Macmillan, New York, N.Y., 2007

[Manyika et. al., 2013]
Manyika, James; Chui, Michael; Bughin, Jacques; Dobbs, Richard; Bisson, Peter; Marrs, Alex: ”Disruptive technologies: Advances that will transform life, business and the global economy”, McKinsey&Company, 2013
http://www.mckinsey.com/insights/business_technology/disruptive_technologies
Accessed: 11.07.2017

[Morner, 1997]
Morner, Michèle: "Organisation der Innovation im Konzern - Gestaltung von Konzernstrukturen zur Hervorbringung von Produktinnovationen", Gabler Verlag, Deutscher Universitätsverlag, Wiesbaden, 1997

[Müller & Karevska, 2016]
Müller, Dr. Andreas; Karevska, Stefana: ”EY's Global 3D Printing Report 2016”, Ernst & Young, 19.07.2016
http://www.ey.com/Publication/vwLUAssets/ey-praesentation-3d-druck/$FILE/ey-praesentation-3d-druck.pdf
Accessed: 08.07.2017

[Peteraf & Bergen, 2003]
Peteraf, Margaret R.; Bergen, Mark E.: ”Scanning Dynamic Competitive Landscapes: A Market-based and Resource-based Framework”, Tuck School of Business at Dartmouth, 2003
https://papers.ssrn.com/sol3/papers.cfm?abstract_id=386602
Accessed: 10.07.2017

[Peterson, 3.2.2016]
Peterson, Eric: "Titan Robotics Company Profile", 3.2.2016
https://companyweek.com/company-profile/titan-robotics
Accessed: 03.08.2017

[Porter, 1980]
Porter, Michael E.: "Competitive Strategy: Techniques for Analyzing Industries and Competitors", The Free Press McMillan Publishing Co., New York, New York, 1980

[PWC, 2014]
Price Waterhouse Coopers; Manufacturing Institute: "3D printing and the new shape of industrial manufacturing", PriceWaterhouseCoopers LLP, 2014
http://www.pwc.com/us/en/industrial-products/assets/3d-printing-next_manufacturing-pwc.pdf
Accessed: 01.07.2017

[PWC, 2016]
PriceWaterhouseCoopers:"Räpresentative Bevölkerungsbefragung 3D Druck 2016", PriceWaterhouseCoopers Aktiengesellschaft Wirtschaftsprüfungsgesellschaft, Frankfurt, 2016
https://www.pwc.de/de/digitale-transformation/assets/bevoelkerungsbefragung-3d-druck.pdf
Accessed: 18.07.2017

[Reichelt & TNS, 2015]
Reichelt Electronic; TNS Enmid: "Studie 3D-Druck", Reichelt Elektronik, 2015

[Robinson et. al., 1994]
Robinson, William T.; Kalyanaram, Gurumurthy; Urban, Glen L.: ”First-Mover Advantages from Pioneering New Markets: A Survey of Empirical Evidence” in Review of Industrial Organization Vol. 9, No. 1, February 1994, Kluwer Academic Publishers, 1994, pp. 1-23

[Rogers, 2003]
Rogers, Everett M.: ”Diffusion of Innovations”, 5th edition, The Free Press, A Division of Simon & Schusters, Inc., New York, NY, 2003

[RolandBerger, 2013]
RolandBerger: “Additive Manufacturing – A game changer for the manufacturing industry?”, RolandBerger Strategy Consultants, Munich, 2013
http://www.rolandberger.com/media/pdf/Roland_Berger_Additive_Manufacturing_Opportunities_in_a_digitalized_production_20150714.pdf
Accessed: 01.07.2017

[Rüggeberg, 1997]
Rüggeberg, Harald: "Strategisches Markeintrittsverhalten junger Technologieunternehmen", Betriebswirtschaftlicher Verlag Dr. Th. Gabler GmbH, Wiesbaden, 1997

[SABL, n.d.]
Statistische Ämter des Bundes und der Länder [SABL]: ”Methodische Grundlagen, Definitionen und Qualität des statistischen Unternehmensregisters”
http://www.statistik-portal.de/Statistik-Portal/de_entMethDef.asp#meth
Date Accessed: 28.07.2017

[Saunders, 12.01.2017]
Saunders, Sarah: "Titan Robotics' Large-Format 3D Printer, the Cronus, Features Five Print Heads and Autodesk Netfabb Software"; 3DR Holdings, LLC, 12.01.2017
https://3dprint.com/161412/titan-cronus-five-print-heads/
Accessed: 03.08.2017

[sciencedirect.com, 2017]
Sciencedirect.com: Literary search, refinement "journals" for terms "fused deposition modeling", "material extrusion", "fused filament fabrication", "additive manufacturing", "3d printing", in business management and accounting, economics, economics and finance
www.sciencedirect.com
Accessed 12.07.2017

[Stratasys, 1989]
Stratasys, Inc.: "Modeling apparatus for three-dimensional objects", Patent No. US 5340433 A
https://www.google.com/patents/US5340433
Accessed: 22.07.2017

[Stratasys, 1994]
Stratasys, Inc.: "Process of support removal for fused deposition modeling", Patent No. US 5503785 A
http://www.google.com/patents/US5503785
Accessed: 22.07.2017

[Tromsdforff & Steinhoff, 2013]
Tromsdorff, Volker; Steinhoff, Fee: “Innovationsmarketing”, Verlag Franz Vahlen GmbH, 2nd. edition, Munich, 2013

[Thewisen et. al., 2016]
Thewisen, Frank; Karevska, Stefana; Czok, Alexandra; Pateman-Jones, Chris; Krauss, Daniel: ”If 3D printing has changed the industries of tomorrow, how can your organization get ready today?” EYGM Limited, 2016
http://www.ey.com/Publication/vwLUAssets/ey-3d-printing-report/$FILE/ey-3d-printing-report.pdf
Accessed: 27.07.2017

[Titan Robotics, 2016]
TITAN Robotics: "Request a quote for your print job", Titan Robotics, n.d.
http://www.titan3drobotics.com/service-bureau/#print-job
Accessed: 05.08.2017

[Titan Robotics, 2016a]
TITAN Robotics: "The Atlas", TITAN Robotics, n.d.
http://www.titan3drobotics.com/atlas/
Accessed: 05.08.2017

[Titan Robotics, 2017]
TITAN Robotics: "We're using our pellet extrusion system to print….", Titan Robotics, 2017
https://www.linkedin.com/feed/update/urn:li:activity:6285249019279134721/
Accessed: 05.08.2017

[Urban et. al, 1986]
Urban, Glen L.; Carter, Theresa; Gaskin, Steven; Mucha, Zofia: "Market Share Rewards to Pioneering Brands - An Empirical Analysis and Strategic Implications" Journal of Management Science, Vol. 32, No 6, June 1986, pp. 645-659

[USPTO, n.d.]
United States Patent and Trademark Office [uspto]:"Patent Term Calculator", United States Patent and Trademark Office, n.d.
https://www.uspto.gov/patent/laws-and-regulations/patent-term-calculator
Accessed: 17.07.2017

[VDMA, 2015]
VDMA Betriebswirtschaft: “VDMA- Kennzahlen vergleichen, verstehen, verändern Rechnungswesen 2015”, VDMA Verband Deutscher Maschinen- und Anlagenbau e. V., Frankfurt, 2015
https://www.vdma.org/documents/105628/11165174/BwZ%2021%20Rechnungswesen%202015.pdf/f1f5ee53-a228-4a2c-aae0-ed8f6b6f59d4
Accessed: 17.07.2017

[Weber, 1976]
Weber, John A.: ”Growth Opportunity Analysis”, Reston Publishing Company, Inc., Preston, VA, 1976

[Weller et. al., 2015]
Weller, Christian; Kleer, Robin; Piller, Frank T.: ”Economic implications of 3D printing: Market structure models in light of additive manufacturing revisited”, in: International Journal of Production Economics, Vol. 164 (2015), pp. 43-56

[Weller, 2015]
Weller, Christian: ”Economic Perspectives on 3D Printing”, Dissertation, Rheinisch-Westfälische Technische Hochschule, Aachen, 2015
https://publications.rwth-aachen.de/record/481083/files/481083.pdf
Accessed: 11.07.2017

[Wohlers & Caffrey, 2014]
Wohlers, Terry; Caffrey, Tim (principal authors): ”Wohlers Report 2014 – 3D Printing and Additive Manufacturing State of the Industry”, Wohlers Associates, Inc., Fort Collins, CO, 2014

[Wohlers, 2010]
Wohlers, Terry: “Wohlers Report 2010 – Additive Manufacturing State of the Industry – Annual Worldwide Progress Report”, Wohlers Associates, Inc., Fort Collins, CO, 2014

V Appendix

Contents

I. Survey Invitation Email

From: [redacted]

Betr.: Bachelor Thesis Umfrage: Nutzung von 3D-Druck in Unternehmen in Deutschland / an die Geschäftsleitung

Sehr geehrte Damen und Herren,

mein Name ist Florian Kappmeier und ich schreibe meine Abschlussarbeit für den Studiengang "Außenwirtschaft und Internationales Management" an der Hochschule für angewandte Wissenschaften Hamburg in Hamburg.

Im Rahmen dieser Arbeit führe ich eine Umfrage durch und untersuche den deutschen Markt für 3D-Drucker, speziell die aktuelle und geplante Nutzung dieser Geräte innerhalb der Unternehmen.

Ich würde mich freuen, wenn Sie an dieser Umfrage teilnehmen:

https://www.umfrageonline.com/s/3ddruck

Die Bearbeitungszeit beträgt unter fünf Minuten.

Ziel meiner Thesis ist es, herauszufinden, welche Gerätetypen sich zur Zeit im Einsatz befinden und wie hoch der Anteil der benutzenden Unternehmen ist.

Dies bedeutet, dass sowohl Antworten von Unternehmen interessant sind, die 3D-Druck nutzen, als auch von solchen die es nicht tun.

In der Literatur finden sich Informationen über den Anteil der Betriebe, die 3D-Druck nutzen, jedoch nicht wie die nutzenden Unternehmen aufgestellt sind und in wie fern Unternehmen zu einer bestimmten Technik tendieren.

Die Teilnahme an der Umfrage erfolgt anonym, d.h. weder aus den erhobenen Daten noch aus den Ergebnissen ist ein Rückschluss auf das Unternehmen möglich.

Selbstverständlich lasse ich Ihnen nach Abschluss der Arbeit die Ergebnisse der Umfrage gerne zukommen. Wenn Sie Interesse an den Ergebnissen der Umfrage haben, kontaktieren Sie mich bitte unter [redacted]

Vielen Dank.

Mit freundlichen Grüßen

Florian Kappmeier

II. Survey Invitation Reminder Email

From: [redacted]

Betr.: Reminder: Bachelor Thesis Umfrage: Nutzung von 3D-Druck in Unternehmen in Deutschland / an die Geschäftsleitung

Sehr geehrte Damen und Herren,

vielen Dank für die erfolgten Teilnahmen und die Rückmeldung zu dieser Umfrage, insbesondere für das konstruktive Feedback und die zahlreichen Erläuterung im Kommentarfeld.

Falls Sie sich bis jetzt noch nicht an der Umfrage beteiligt haben, freue ich mich, wenn Sie meine Abschlussarbeit dahingehend unterstützen, bis zum 7.8.2017 den Onlinefragebogen auszufüllen:

https://www.umfrageonline.com/s/3ddruck

Die Bearbeitungszeit beträgt unter fünf Minuten.

Ziel meiner Thesis ist es, herauszufinden, welche Gerätetypen von 3D-Druckern sich zurzeit im Einsatz befinden und wie hoch der Anteil der benutzenden Unternehmen ist.

Dies bedeutet, dass sowohl Antworten von Unternehmen für mich wichtig sind, die 3D-Druck nutzen, als auch von solchen die es nicht tun.

In der Literatur finden sich Informationen über den Anteil der Betriebe, die 3D-Druck nutzen, jedoch nicht wie die nutzenden Unternehmen aufgestellt sind und in wie fern Unternehmen zu einer bestimmten Technik tendieren.

Die Teilnahme an der Umfrage erfolgt anonym, d.h. weder aus den erhobenen Daten noch aus den Ergebnissen ist ein Rückschluss auf das Unternehmen möglich.

Um die Anonymität zu gewährleisten, habe ich auf ein Eingabefeld für Kontaktdaten verzichtet. Selbstverständlich lasse ich Ihnen nach Beendigung der Bachelorarbeit die Ergebnisse der Umfrage gerne zukommen. Wenn Sie Interesse an den Ergebnissen der Umfrage haben, senden Sie mir bitte eine separate Email an [redacted]

Vielen Dank für Ihre Unterstützung.

Mit freundlichen Grüßen

Florian Kappmeier

III. Survey Questionnaire Flowchart

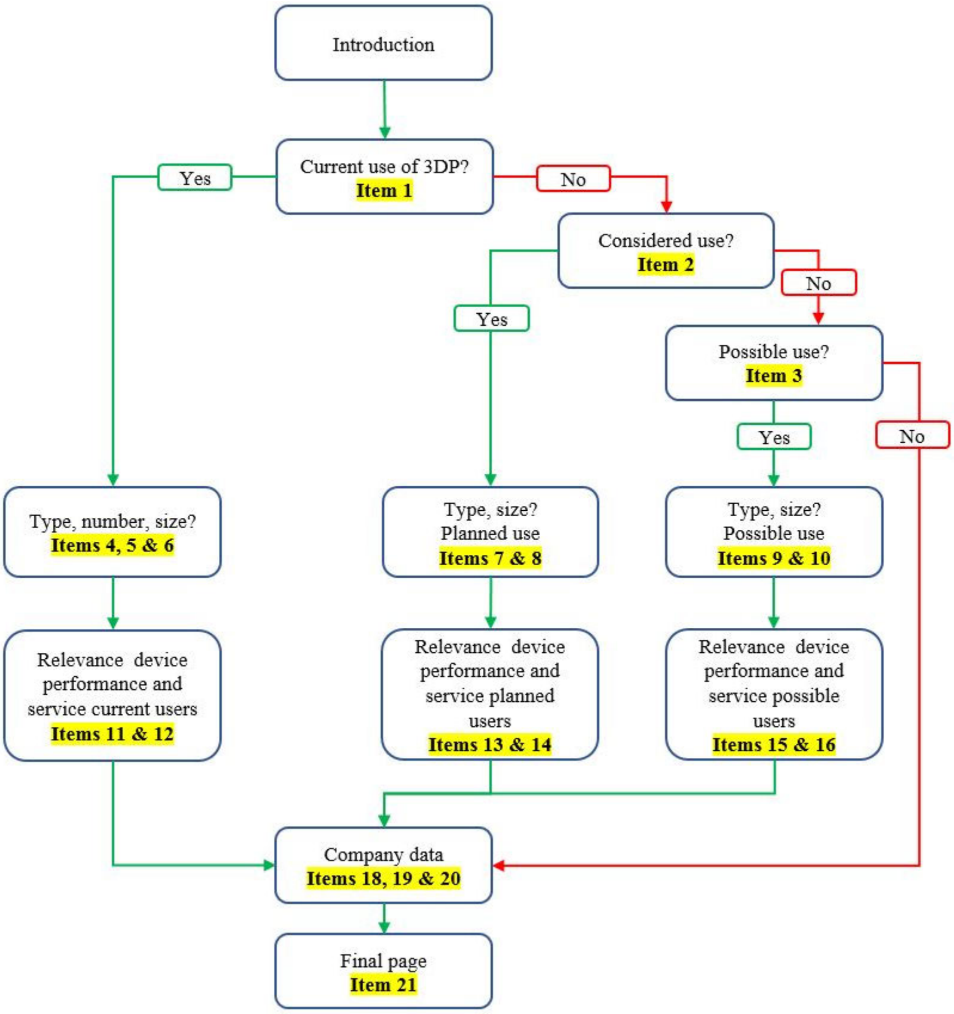


Figure 11 - Questionnaire Flow Chart

The survey follows a systematic approach by steering participants through the questions based on their previous answers. Following the introduction, item one as a mandatory yes or no question, checks whether the company is currently using 3DP.

If the answer to item one is “yes”, participants are classified as “current users” and item four gathers the process types in use, item five the number of devices in use for each process type and item six the size of the largest device in use. After this, item eleven collects data on the importance of varying device properties and item twelve about the relevance of customer service.

If the answer to item one is “no”, participants are asked via item two if they considered the use of 3DP in their companies within the past twelve months.

If the answer to item two is “yes”, participants are classified as “potential users” and items seven and eight gather information about process types and build size the company is interested in (analog to items four and five). After this, items 13 and 14 are analog to items eleven and twelve.

If the answer to item two is “no”, item three asked whether the participants “can imagine” the use of 3DP in their companies. If their reply is “yes”, participants are classified as “possible users” and the flow via items nine and ten as well as 15 and 16 is analog to items 13 and 14.

If the answer to item three is “no”, participants are not classified as either current-, possible-, or potential users: The flow is then directly forwarded to items 18, 19, and 20.

Starting with item 18, the flow of participants is reunited is reunited. Item 18 gathers the total number of employees, item 19 the number of technical employees and item 20 the branch of the participant. Item 21 is used as a free text field for comments and recommendations to provide the participants a chance for feedback, however this item is not included into the survey evaluation.

IV. Survey Data Preparation

Since multiple items in the survey gather the same information from “current-, considered-, and possible users” (see flowchart), items one, two and three are used to distinguish the data. Thus, the following items, including their subitems, are combined for analysis:

Item four, seven and nine, further on referred to as Item four. Items six, eight and ten, combined in item five, items eleven, 13, and 15, summarized in item eleven and items twelve, 14 and 16 added in item twelve.

Furthermore, items one, two and three are used to create the variable “user type”, where 1=current user, 2=considered users and 3=possible user. As the companies that are not interested in AM are not the aim of this survey, no class for “uninterested” participants is included. Also, the usage incidence of other than FFF devices is not analyzed.

V. Survey Questionnaire

Figure 12 - Survey Questionnaire and Items
Item numbers added in red

Einleitung

Vielen Dank, dass Sie an dieser Umfrage Teilnehmen.
Jede vollständige Antwort eines teilnehmenden Unternehmens erhöht die Qualität der Ergebnisse meiner Abschlussarbeit.
Wenn Sie die Ergebnisse der Umfrage erhalten möchten, senden Sie mir bitte eine Email. Die Kontaktdaten finden Sie am Ende der Umfrage.

Ziel der Umfrage ist es, herauszufinden, welche Typen von 3D-Druckern sich zur Zeit im Einsatz befinden und wie hoch der Anteil der benutzenden Unternehmen ist. Dies bedeutet, dass sowohl Antworten von Unternehmen interessant sind, die 3D-Druck nutzen, als auch von solchen die es nicht tun.

Die Bearbeitungsdauer beträgt unter 5 Minuten und die Teilnahme an der Umfrage erfolgt anonym, d.h. weder aus den erhobenen Daten noch aus den Ergebnissen ist ein Rückschluss auf das Unternehmen möglich. Bitte kontaktieren Sie mich bei Fragen direkt über meine am Ende der Umfrage angegeben Emailadresse.

Mit freundlichen Grüßen

Florian Kappmeier

Aktueller Einsatz von 3D Druckern (Seite 1)

Nutzen Sie beziehungsweise Ihr Unternehmen zur Zeit additive Fertigungsmethoden (3D-Druck)? *

Diese Frage ist eine Pflichtfrage, da sie für den weiteren Verlauf des Fragebogens unerlässlich ist. Alle anderen Fragen dieser Umfrage sind keine Pflichtfragen.

Item 1

- ◯ ja
- ◯ nein

Geplanter Einsatz von 3D-Druckern (Seite 2)

Haben Sie in den letzten 12 Monaten den Einsatz von 3D-Druckern in Ihrem Unternehmen in Betracht gezogen?

Item 2

- ◯ ja
- ◯ nein

Möglicher Einsatz von 3D Druckern (Seite 3)

Können Sie sich vorstellen, in Ihrem Betrieb 3D Drucker einzusetzen?

- ◯ ja
- ◯ nein

Item 3

Aktueller Einsatz von 3D-Druckern

Welche Verfahrenstypen setzen Sie ein?

Zur Klärung der Begriffe können Sie auf die jeweilige Antwort klicken. Diese leitet sie auf den entsprechenden Wikipedia Artikel weiter.

Item 4

- ☐ Binder Jetting (https://de.wikipedia.org/wiki/Binder_Jetting)
- ☐ FDM - Fused Deposition Modeling (https://de.wikipedia.org/wiki/Fused_Deposition_Modeling)
- ☐ Polyjet Modeling (https://de.wikipedia.org/wiki/Multi_Jet_Modeling)
- ☐ SLS - Selektives Laser Sintering (https://de.wikipedia.org/wiki/Selektives_Lasersintern)
- ☐ SLM - Selektives Laserschmelzen (https://de.wikipedia.org/wiki/Selektives_Laserschmelzen)
- ☐ SLA - Sterelithografie (https://de.wikipedia.org/wiki/Stereolithografie)
- ☐ Andere [ ]

Wie viele Gerät des jeweiligen Typs haben Sie im Einsatz?

Bitte geben Sie hier die Anzahl der Geräte der oben genannten Gerätetypen ein.

Item 5

	Anzah der Geräte
Binder Jetting	
FDM - Fused Deposition Modeling	
Polyjet Modeling	
SLS - Selektives Laser Sintering	
SLM - Selektives Laserschmelzen	
SLA - Sterelithografie	
Andere	

Welche Bauraumgröße besitzen die eingesetzen Geräte? Bei unterschiedlichen Größen geben Sie bitte das größte Gerät an.

Die Bauraumgröße bestimmt die maximale Größe der in einem Arbeitsgang produzierbaren Teile (Analog zum Druckbereich eines "Papierdruckers"). Bitte stellen Sie sich den Baurum des Druckers als Würfel vor. Welche Kantenlänge besitzt er ungefähr?

Item 6

- ◯ 500x500x500 mm oder kleiner (bis 125 l Bauvolumen)
- ◯ bis 800x800x800 mm (bis 512 l Bauvolumen)
- ◯ bis 900x900x900 mm (bis 729 l Bauvolumen)
- ◯ bis 1000x1000x1000 mm (bis 1.000 l Bauolumen)
- ◯ größer als 1000x1000x1000 mm (über 1.000 l Volumen)
- ◯ Andere [ ]

Geplanter Einsatz von 3D-Druckern

Welche Verfahrenstypen sind für Sie / Ihr Unternehmen interessant?

Zur Klärung der Begriffe können Sie auf die jeweilige Antwort klicken. Diese leitet sie auf den entsprechenden Wikipedia Artikel weiter.

Item 7

- ☐ Binder Jetting (https://de.wikipedia.org/wiki/Binder_Jetting)
- ☐ FDM - Fused Deposition Modeling (https://de.wikipedia.org/wiki/Fused_Deposition_Modeling)
- ☐ Polyjet Modeling (https://de.wikipedia.org/wiki/Multi_Jet_Modeling)
- ☐ SLS - Selektives Laser Sintering (https://de.wikipedia.org/wiki/Selektives_Lasersintern)
- ☐ SLM - Selektives Laserschmelzen (https://de.wikipedia.org/wiki/Selektives_Laserschmelzen)
- ☐ SLA - Sterelithografie (https://de.wikipedia.org/wiki/Stereolithografie)
- ☐ Andere [ ]

Welche Bauraumgröße wäre für Sie interessant?

Die Baugröße bestimmt die maximale Größe der in einem Arbeitsgang produzierbaren Teile (Analog zum Druckbereich eines "Papierdruckers"). Bitte stellen Sie sich den Baurum des Druckers als Würfel vor. Welche Kantenlänge besitzt er ungefähr?

Item 8

- ◯ 500x500x500 mm oder kleiner (bis 125 l Bauvolumen)
- ◯ bis 800x800x800 mm (bis 512 l Bauvolumen)
- ◯ bis 900x900x900 mm (bis 729 l Bauvolumen)
- ◯ bis 1000x1000x1000 mm (bis 1.000 l Bauolumen)
- ◯ größer als 1000x1000x1000 mm (über 1.000 l Volumen)
- ◯ Andere [ ]

Möglicher Einsatz von 3D-Druckern

Welche Verfahrenstypen sind für Sie / Ihr Unternehmen interessant?

Zur Klärung der Begriffe können Sie auf die jeweilige Antwort klicken. Diese leitet sie auf den entsprechenden Wikipedia Artikel weiter.

Item 9

- ☐ Binder Jetting (https://de.wikipedia.org/wiki/Binder_Jetting)
- ☐ FDM - Fused Deposition Modeling (https://de.wikipedia.org/wiki/Fused_Deposition_Modeling)
- ☐ Polyjet Modeling (https://de.wikipedia.org/wiki/Multi_Jet_Modeling)
- ☐ SLS - Selektives Laser Sintering (https://de.wikipedia.org/wiki/Selektives_Lasersintern)
- ☐ SLM - Selektives Laserschmelzen (https://de.wikipedia.org/wiki/Selektives_Laserschmelzen)
- ☐ SLA - Sterelithografie (https://de.wikipedia.org/wiki/Stereolithografie)
- ☐ Andere ________

Welche Bauraumgröße wäre für Sie interessant?

Die Baugröße bestimmt die maximale Größe der in einem Arbeitsgang produzierbaren Teile (Analog zum Druckbereich eines "Papierdruckers"). Bitte stellen Sie sich den Baurum des Druckers als Würfel vor. Welche Kantenlänge besitzt er ungefähr?

Item 10

- ○ 500x500x500 mm oder kleiner (bis 125 l Bauvolumen)
- ○ bis 800x800x800 mm (bis 512 l Bauvolumen)
- ○ bis 900x900x900 mm (bis 729 l Bauvolumen)
- ○ bis 1000x1000x1000 mm (bis 1.000 l Bauolumen)
- ○ größer als 1000x1000x1000 mm (über 1.000 l Volumen)
- ○ Andere ________

Relevanz der Geräteleistung und des Herstellerservice bei aktuellem Einsatz

Bitte bewerten Sie die Relevanz der folgenden Gerätekenngrößen mit 0 - 100 Punkten, wobei 0 Punkte der Aussage "Ist mir garnicht wichtig" und 100 Punkte der Aussage "Ist mir absolut wichtig / notwendig" ensprechen.

Item 11

	Relevanz (0-100)
Baugeschwindigkeit	☐
Verfügbarer Bauraum	☐
Baugenauigkeit des Geräts (analog zur Bildauflösung eines Druckers)	☐
Gleichzeitiger Druck mit verschiedenen Materialien	☐

Wie wichtig ist Ihnen der Kundenservice bei der Betrachtung einer möglichen Kaufentscheidung für einen 3D-Drucker? Bitte bewerten Sie die folgenden Aussagen mit 0 - 100 Punkten, wobei 0 Punkte der Aussage "Ist mir garnicht wichtig" und 100 Punkte der Aussage "Ist mir absolut wichtig / notwendig" ensprechen.

Item 12

	Punkte (0-100)
Regelmäßige Updates für die Firmware (das Betriebssystems) des 3D-Druckers durch den Hersteller	☐
Regelmäßige Informationen über technische Neuerungen und Erweiterungsmöglichkeiten	☐
Angebotener Wartungsdienst	☐
Schulung des Personals zur Verwendung und Einstellung des 3D-Druckers	☐
Schulungen und Seminare zur optimierung der Modellentwürfe ("Druckgerechtes Konstruieren")	☐
Angebotener Montage- und Einrichtungsdienst	☐

Relevanz der Geräteleistung und des Herstellerservice bei geplantem Einsatz

Bitte bewerten Sie die Relevanz der folgenden Gerätekenngrößen mit 0 - 100 Punkten, wobei 0 Punkte der Aussage "Ist mir garnicht wichtig" und 100 Punkte der Aussage "Ist mir absolut wichtig / notwendig" ensprechen.

Item 13

	Relevanz (0-100)
Baugeschwindigkeit	☐
Verfügbarer Bauraum	☐
Baugenauigkeit des Geräts (analog zur Bildauflösung eines Druckers)	☐
Gleichzeitiger Druck mit verschiedenen Materialien	☐

Wie wichtig ist Ihnen der Kundenservice bei der Betrachtung einer möglichen Kaufentscheidung für einen 3D-Drucker? Bitte bewerten Sie die folgenden Aussagen mit 0 - 100 Punkten, wobei 0 Punkte der Aussage "Ist mir garnicht wichtig" und 100 Punkte der Aussage "Ist mir absolut wichtig / notwendig" ensprechen.

Item 14

	Punkte (0-100)
Regelmäßige Updates für die Firmware (das Betriebssystems) des 3D-Druckers durch den Hersteller	
Regelmäßige Informationen über technische Neuerungen und Erweiterungsmöglichkeiten	
Angebotener Wartungsdienst	
Schulung des Personals zur Verwendung und Einstellung des 3D-Druckers	
Schulungen und Seminare zur optimierung der Modellentwürfe ("Druckgerechtes Konstruieren")	
Angebotener Montage- und Einrichtungsdienst	

Relevanz der Geräteleistung und des Herstellerservice bei möglichem Einsatz

Bitte bewerten Sie die Relevanz der folgenden Gerätekenngrößen mit 0 - 100 Punkten, wobei 0 Punkte der Aussage "Ist mir garnicht wichtig" und 100 Punkte der Aussage "Ist mir absolut wichtig / notwendig" ensprechen.

Item 15

	Relevanz (0-100)
Baugeschwindigkeit	
Verfügbarer Bauraum	
Baugenauigkeit des Geräts (analog zur Bildauflösung eines Druckers)	
Gleichzeitiger Druck mit verschiedenen Materialien	

Wie wichtig ist Ihnen der Kundenservice bei der Betrachtung einer möglichen Kaufentscheidung für einen 3D-Drucker? Bitte bewerten Sie die folgenden Aussagen mit 0 - 100 Punkten, wobei 0 Punkte der Aussage "Ist mir garnicht wichtig" und 100 Punkte der Aussage "Ist mir absolut wichtig / notwendig" ensprechen.

	Punkte (0-100)
Regelmäßige Updates für die Firmware (das Betriebssystems) des 3D-Druckers durch den Hersteller	
Regelmäßige Informationen über technische Neuerungen und Erweiterungsmöglichkeiten	
Angebotener Wartungsdienst	
Schulung des Personals zur Verwendung und Einstellung des 3D-Druckers	
Schulungen und Seminare zur optimierung der Modellentwürfe ("Druckgerechtes Konstruieren")	
Angebotener Montage- und Einrichtungsdienst	

Item 16

Unternehmensdaten

In welcher Branche / in welchen Branchen ist Ihr Unternehmen tätig?

Bei mehreren Branchen wählen Sie bitte die Branche, welche Ihrem Hauptgeschäft am nächsten liegt.

- ◯ Formenbau
- ◯ Herstellung von Kunststoffprodukten
- ◯ Industriedesign
- ◯ Kraftfahrzeugherstllung
- ◯ Maschinenbau und Apparatebau
- ◯ Modellbau
- ◯ Produktdesign
- ◯ Prototypenbau
- ◯ Werkzeugbau
- ◯ Keine Angabe
- ◯ Andere (bitte benennen): ____

Item 17

Wie viele Mitarbeiter beschäftigt Ihr Unternehmen insgesamt?

Bei Enhaltung tragen Sie bitte den Wert "0" in das Textfeld

Item 18

Wie viele Personen sind im technischen Bereich tätig?

Bei Enhaltung tragen Sie bitte den Wert "0" in das Textfeld

Item 19

Wie hoch ist der ungefähre Jahresumsatz ihres Unternehmens?

- bis unter 250.00 €
- 250.000 bis 500.000 €
- 500.000 € bis 1 Mil.
- 1 Mil. bis 2 Mil.
- 2 Mil. bis 5 Mil.
- 5 Mil. bis 10 Mil.
- 10 Mil. bis 25 Mil.
- 25 Mil. bis 100 Mil.
- über 100 Mil.
- Keine Angabe

Item 20

Vielen Dank für Ihre Teilnahme. Möchten Sie die Umfrageergebnisser per Email erhalten?

Gerne lasse ich Ihnen die Ergebnisse dieser Umfrage zukommen. Bitte senden Sie dazu eine Email mit dem Betreff "Umfrageergebnisse 3D-Druck" und Ihren Kontaktdaten an florian.kappmeier@haw-hamburg.de

Bitte klicken Sie auf "Fertig" um die Umfrage zu beenden.

Item 21

Hier haben Sie die Möglichkeit, ein Kommentar zu hinterlassen

» **Umleitung auf Schlussseite von Umfrage Online** (ändern)

VI. Additional Tables and Figures

		Frequency	Percent	Valid Percent	Cumulated Percent
Valid	binder jetting	23,00	5,24	5,24	5,24
	directed energy deposition	17,00	3,87	3,87	9,11
	FFF	184,00	41,91	41,91	51,03
	Film Transfer Imaging	1,00	0,23	0,23	51,25
	GDP	1,00	0,23	0,23	51,48
	Laser	3,00	0,68	0,68	52,16
	LCM	2,00	0,46	0,46	52,62
	Material extrusion	2,00	0,46	0,46	53,08
	Material extrusion with photocuring	2,00	0,46	0,46	53,53
	Material Jetting	32,00	7,29	7,29	60,82
	NA	1,00	0,23	0,23	61,05
	powder bed fusion	62,00	14,12	14,12	75,17
	sheet lamination	7,00	1,59	1,59	76,77
	SLA	6,00	1,37	1,37	78,13
	SLS	1,00	0,23	0,23	78,36
	VAT	95,00	21,64	21,64	100,00
	Total	439,00	100,00	100,00	

Table 9 - Frequency of Process Types

		Frequency	Percent	Valid Percent	Cumulated Percent
Valid	ceramics	6,00	1,37	1,37	1,37
	metals	49,00	11,16	11,16	12,53
	not available	1,00	0,23	0,23	12,76
	other	42,00	9,57	9,57	22,32
	photopolymers	94,00	21,41	21,41	43,74
	plastics	247,00	56,26	56,26	100,00
	Total	439,00	100,00	100,00	

Table 10 - Frequency of Material Class

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	14	3.2	21.9	21.9
	2	11	2.5	17.2	39.1
	3	10	2.3	15.6	54.7
	4	15	3 4	23 4	78 1
	5	14	3 2	21 9	100 0
	Total	64	14.6	100.0	
Missing	System	375	85,4		
Total		439	100,0		

Table 11 - Frequency of Build Volume Class

	Mean Values of Build Volume Class				
	1	2	3	4	5
	Mean	Mean	Mean	Mean	Mean
Build Vol [l]	149,8	210,1	282,9	473,1	948,7

Table 12 - Mean Values of Build Volume Class

		4b: FDM [FFF]			
		No FFF Use		FFF Use	
		Count	Table N %	Count	Table N %
UserType	no use info	17	15,5%	0	,0%
	current user	25	22,7%	36	32,7%
	considered user	8	7,3%	9	8,2%
	possible user	13	11,8%	2	1,8%

Table 13 - Usage Frequency of Fused Filament Fabrication by User Type

Model Summary General Additive Manufacturing Users

Specifications	Growing Method	EXHAUSTIVE CHAID
	Dependent Variable	Users Yes/No
	Independent Variables	18: Number of employees, 19: Number of technical employees, 17: Industry branch, Build Size Class, Item 20: How large is your approximate annual turnover?
	Validation	None
	Maximum Tree Depth	3
	Minimum Cases in Parent Node	10
	Minimum Cases in Child Node	5
Results	Independent Variables Included	No Independent Variable Included
	Number of Nodes	1
	Number of Terminal Nodes	1
	Depth	0
	Risk estimate	0.445
	Standard error	0.047

Table 14 - Model Summary for General Additive Manufacturing Users

Model Summary Fused Filament Users Classification

Specifications	Growing Method	EXHAUSTIVE CHAID
	Dependent Variable	4b: FDM
	Independent Variables	17: Industry branch, UserType, 19: Number of technical employees, 18: Number of employees, Item 20: Approximate annual turnover
	Validation	None
	Maximum Tree Depth	3
	Minimum Cases in Parent Node	10
	Minimum Cases in Child Node	5
Results	Independent Variables Included	17: Industry branch, UserType
	Number of Nodes	5
	Number of Terminal Nodes	3
	Depth	2
	Risk estimate	0.226
	Std.- Error	0.043

Table 15 - Model Summary of Fused Filament User Classification

Model Summary of Large Scale Fused Filament Fabrication Users

Specifications	Growing Method	EXHAUSTIVE CHAID
	Dependent Variable	Build Size Class
	Independent Variables	Annual Turnover, 17: Industry branch, 19: Number of technical employees, 18: Number of employees
	Validation	None
	Maximum Tree Depth	3
	Minimum Cases in Parent Node	10
	Minimum Cases in Child Node	5
Results	Independent Variables Included	17: Industry branch
	Number of Nodes	5
	Number of Terminal Nodes	4
	Depth	1
	Risk estimate	0,364
	Std. error	0,046

Table 16 - Model Summary of Large Scale Fused Filament Fabrication Users

Classification of Large Scale Fused Filament Fabrication Users

	Predicted						
Observed	n.a.	500x500x500 or smaller	up to 800x800x800	up to 900x900x900	up to 1000x1000x1000	larger	Percent Correct
n.a.	20	16	0	0	0	0	55,6%
500x500x500 or smaller	4	50	0	0	0	0	92,6%
up to800x800x800	1	8	0	0	0	0	,0%
up to 900x900x900	0	2	0	0	0	0	,0%
up to 1000x1000x1000	2	4	0	0	0	0	,0%
larger	0	3	0	0	0	0	,0%
Overall Percentage	24,5%	75,5%	,0%	,0%	,0%	,0%	63,6%

Table 17 - Classification of Large Scale Fused Filament Fabrication Users

Number	Assumption	Page
(1)	Since 3DP machines are not consumables, for the current perspective (light user gap versus light usage gap), it is not relevant if, when used, they are used to their full potential at any given opportunity	4
(2)	End users of 3DP machines behave as consumers would towards a long-lasting consumer good.	4
(3)	The German consumer and the American consumer are homogenous on their use of rapid manufacturing techniques, thus the markets for these devices are comparable.	13
(4)	The adoption usage rate of consumers is identical with professional users since the answers in the survey [Reichelt & TNS, 2015], since the answers in the survey also include those people working with rapid manufacturing systems	13
(5)	The adoption of rapid manufacturing technology follows Rogers` "normal" scenario	13
(6)	The number of rapid manufacturing devices sold [in a given European nation] correlates to the industrial size (GDP) of that nation as compared to other member states of the EU	15

Table 18 - Table of Assumptions

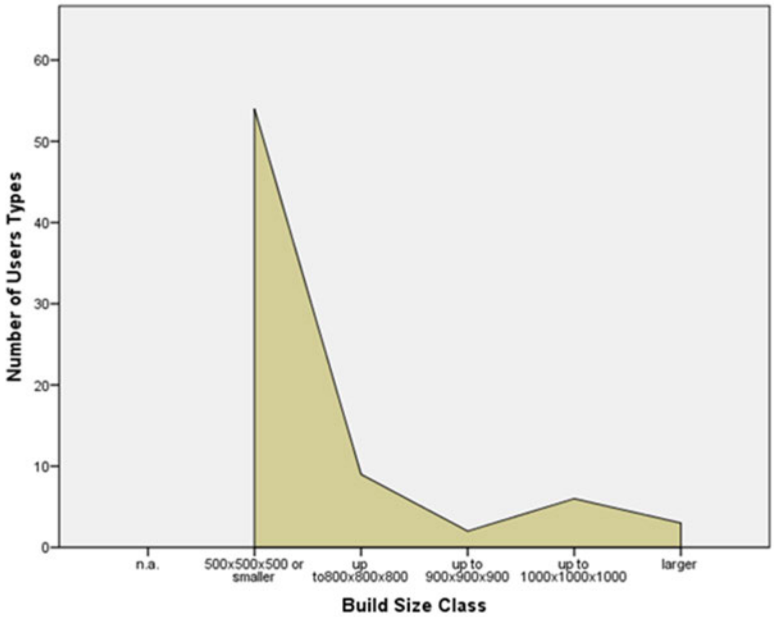


Figure 13 - Number of User Types by Build Size Class

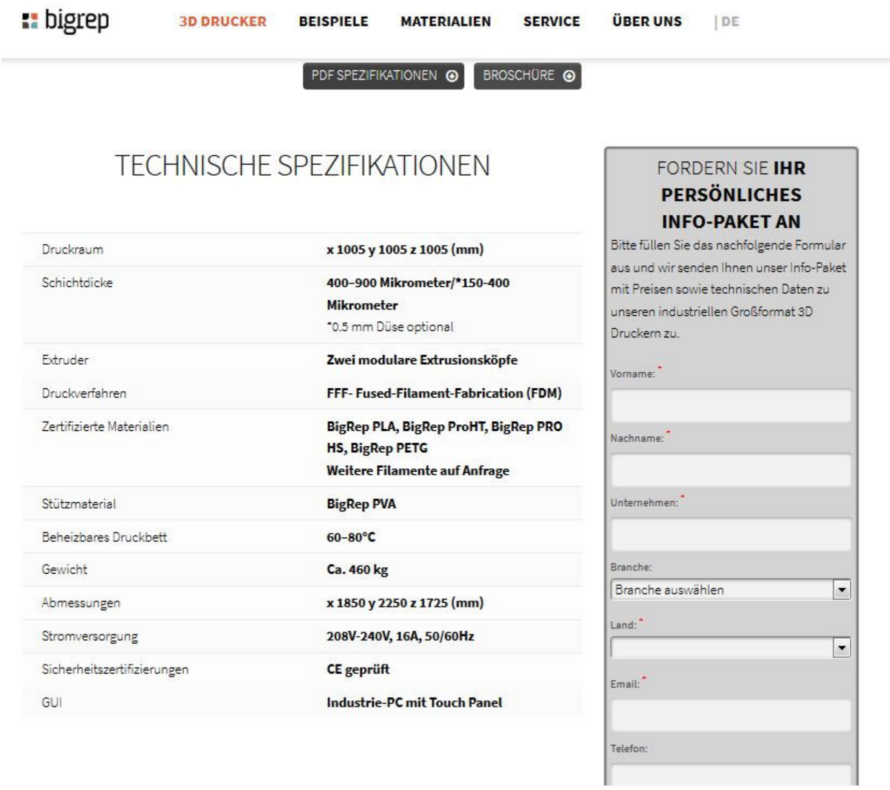
VII. Sources for Market Analysis

In the following, due to space restraints, 15 online sources as screenshots for the in Chapter 3 used device data a given. The complete list of [online] sources and PDF-printouts of the corresponding websites are found in the digital appendix in the file “Device Data Sources.xlsx”. The PDF-files are named with the device name to allow for easy access.

BigRep GmbH: "Technische Spezifikationen BigRep ONE"

https://bigrep.com/wp-content/uploads/2017/01/Technical-Specifications-ONE-de-1.2.pdf

Date Accessed: 26.08.2017



bigrep 3D DRUCKER BEISPIELE MATERIALIEN SERVICE ÜBER UNS | DE

PDF SPEZIFIKATIONEN BROSCHÜRE

TECHNISCHE SPEZIFIKATIONEN

Druckraum	x 1005 y 1005 z 1005 (mm)
Schichtdicke	400–900 Mikrometer/*150-400 Mikrometer *0.5 mm Düse optional
Extruder	Zwei modulare Extrusionsköpfe
Druckverfahren	FFF- Fused-Filament-Fabrication (FDM)
Zertifizierte Materialien	BigRep PLA, BigRep ProHT, BigRep PRO HS, BigRep PETG Weitere Filamente auf Anfrage
Stützmaterial	BigRep PVA
Beheizbares Druckbett	60–80°C
Gewicht	Ca. 460 kg
Abmessungen	x 1850 y 2250 z 1725 (mm)
Stromversorgung	208V-240V, 16A, 50/60Hz
Sicherheitszertifizierungen	CE geprüft
GUI	Industrie-PC mit Touch Panel

FORDERN SIE IHR PERSÖNLICHES INFO-PAKET AN

Bitte füllen Sie das nachfolgende Formular aus und wir senden Ihnen unser Info-Paket mit Preisen sowie technischen Daten zu unseren industriellen Großformat 3D Druckern zu.

Vorname: *

Nachname: *

Unternehmen: *

Branche:

Branche auswählen

Land: *

Email: *

Telefon:

BigRep GmbH: "Technische Spezifikationen BigRep Studio"

https://bigrep.com/wp-content/uploads/2017/01/Technical-Specifications-Studio-de-1.2.pdf

Date Accessed: 26.08.2017

bigrep

THE **LARGE-SCALE** FFF 3D-PRINTER FOR
PROFESSIONAL AND **INDUSTRIAL** USE.

TECHNISCHE SPEZIFIKATIONEN
BigRep Studio

Druckraum	**x 500 y 1000 z 500 (mm)**
Druckgeschwindigkeit	**max. 140mm/s bei 0,1 mm Schichtdicke**
Druckkopfbeschleunigung	**max. 1000mm/s²**
Schichtdicke	**100-400 Mikrometer**
Extruder	**Standard Version: Single Extruder** **Advanced Version: Dual Extruder** (jeweils mit 0,6 mm Düse)
Druckverfahren	**FFF - Fused-Filament-Fabrication (FDM)**
Zertifizierte Materialien	**BigRep PLA, BigRep ProHT, BigRep PETG** Flexible Materialien folgen
Beheizbares Druckbett	**60° C – 80° C**
Gewicht	**ca. 250 kg**
Abmessungen	**x 1022 y 1660 z 1500 (mm)**
Stromversorgung	**208V - 240V, 16A, 50/60Hz**
Sicherheitszertifizierungen	**CE geprüft**
GUI	**Industrie-PC mit Multi Touch Panel**
Datenübertragung	**USB & Netzwerk (RJ45-Stecker)**

Builder 3D Printers B.V.: "Meet the Builder Extreme 1000 & 2000"

http://builder3dprinters.com/wp-content/uploads/2017/07/Builder-Extreme-1000-2000-Flyer.pdf

Date Accessed: 13.07.2017

3D Prints	**Dual-Feed Build Size Extreme 1000** 700 x 700 x 820 mm **Dual-Feed Build Size Extreme 2000** 700 x 700 x 1820 mm **Travel speed** 10 - 200 mm/s **Layer height resolution** 0.05 - 0.6 mm
General Specifications	**Outside dimensions Extreme 1000** 1010 x 1010 x 1500 mm **Outside dimensions Extreme 2000** 1010 x 1180 x 2300 mm **Connections** SD Card, WiFi **Nozzle diameter** 0.4 / 0.8 / 1.2 mm **Print speed** 10 - 120 mm/s **Print bed** Heated bed (20 - 60°) **Extruder** Unique Dual-Feed system Removable extruder **Camera** 480 x 272 pixels
Software	STL Cura, Simplify 3D
3D Print Material	PLA, Woodfill, PVA, Bronzefill, Flex, PET 1.75 mm

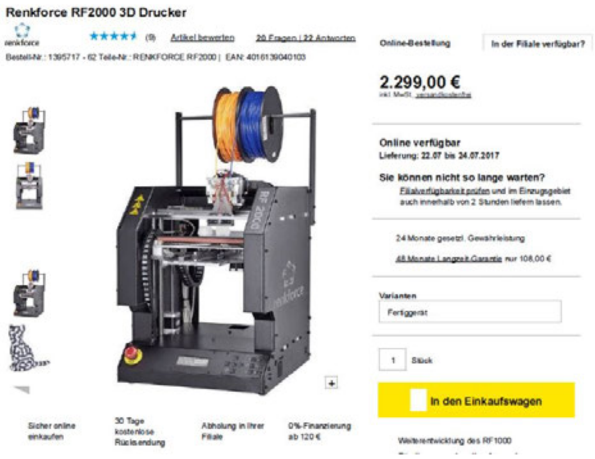
Printing prototypes 24/7

3D printers are the perfect tool to reduce costs and to save time, especially when you can print 24/7. The Builder Extreme is a reliable machine which can print many hours without stopping. The Builder Extreme is already used in the yacht industry but also by architects, product designers and artists. One of the biggest prints made by the Builder Extreme is the iconic Empire State Building. It took 300 hours to print and weighs 15 kg and is 1800 mm high.

Conrad Electronics "Renkforce RF2000"

https://www.conrad.de/de/renkforce-rf2000-3d-drucker-1395717.html

Date Accessed: 13.07.2017



Technische Daten

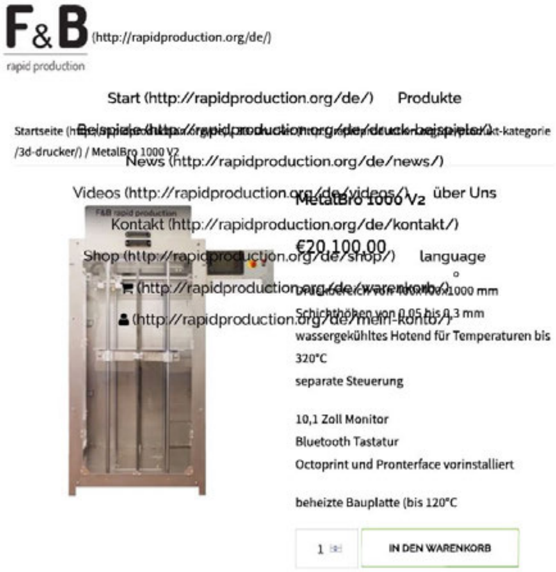
Kategorie	3D Drucker
Ausführung	Fertiggerät
Unterstütztes Druckmaterial	PLA PLA Compounds ABS PETG Polyamid (PA) / Nylon Flex Elastisch HIPS Polycarbonat (PC) PP PVA
Druck-Breite (X) max.	180 mm
Druck-Tiefe (Y) max.	200 mm
Druck-Höhe (Z) max.	230 mm
Druckbett-Eigenschaften	beheizbar wechselbar
Extruder-Typ	Duo
Geeignet für Filament-Ø	2.85 mm 3 mm
Düsen-Ø	0.4 mm
Druckschicht Dicke (min.)	0.05 mm
Druckschicht Dicke (max.)	0.3 mm
SD-Karten Slot	Ja
Schnittstellen	USB 2.0 Netzwerk (Optional über renkforce 3D Printbox)
Software	Open Source (Repetier-Host, Cura), Astroprint (Optional)
Farbe	Schwarz
Gehäuse-Material	Aluminium, Stahl
Breite	375 mm
Höhe	665 mm
Tiefe	410 mm
Gewicht	19.5 kg
Betriebsspannung (Details)	230 V/AC, 50 Hz
Leistungsaufnahme (max.)	620 W
Druckbereich Kurze Seite	150 mm - 200 mm
Druck-Höhen-Bereich (Z)	200 mm - 350 mm
Druckbereich Lange Seite	200 mm - 350 mm

n bei Newsletter-Anmeldung! ×

F&B Rapid Production GmbH: "MetalBro 1000 V2"

http://rapidproduction.org/de/produkt/metalbro-1000-v2/

Date Accessed: 13.07.2017


F&B (http://rapidproduction.org/de/)
rapid production

Start (http://rapidproduction.org/de/) Produkte
Beispiele (http://rapidproduction.org/de/druck-beispiele/)
News (http://rapidproduction.org/de/news/)
Videos (http://rapidproduction.org/de/videos/) über Uns
Kontakt (http://rapidproduction.org/de/kontakt/)
Shop (http://rapidproduction.org/de/shop/) language
(http://rapidproduction.org/de/warenkorb/)
(http://rapidproduction.org/de/mein-konto/)

Startseite / MetalBro 1000 V2

MetalBro 1000 V2

€20.100,00

Druckbereich von 400x400x1000 mm
Schichthöhen von 0,05 bis 0,3 mm
wassergekühltes Hotend für Temperaturen bis 320°C
separate Steuerung

10,1 Zoll Monitor
Bluetooth Tastatur
Octoprint und Pronterface vorinstalliert

beheizte Bauplatte (bis 120°C

1 | IN DEN WARENKORB

Beschreibung

- Druckbereich von 400x400x1000 mm
- Schichthöhen von 0,05 bis 0,3 mm
- wassergekühltes Hotend für Temperaturen bis 320°C
- separate Steuerung
    - 10,1 Zoll Monitor
    - Bluetooth Tastatur
    - Octoprint und Pronterface vorinstalliert
- beheizte Bauplatte (bis 120°C

Ähnliche Produkte



F&B Rapid Production GmbH: "MetalBro 650 V"

http://rapidproduction.org/de/produkt/metalbro-650-v3/

Date Accessed: 13.07.2017

F&B rapid production

+49 ... 71632 support@rapidproduction.org Am Schillertheater 4, 10625 Berlin

(http://rapidproduction.org/de/) Verkauf und Service innerhalb von:

Start (http://rapidproduction.org/de/) Produkte

Beispiele (http://rapidproduction.org/de/druck-beispiele/)

News (http://rapidproduction.org/de/news/)

Videos (http://rapidproduction.org/de/videos/) Über Uns

Startseite (http://rapidproduction.org/de/) / 3D-Drucker (http://rapidproduction.org/de/produkt-kategorie/3d-drucker/) / MetalBro 650 V3

Kontakt (http://rapidproduction.org/de/kontakt/)

Shop (http://rapidproduction.org/de/shop/) language

(http://rapidproduction.org/de/warenkorb/) 0

(http://rapidproduction.org/de/mein-konto/)

MetalBro 650 V3

€17.850,00

1 IN DEN WARENKORB

Kategorie: 3D-Drucker (http://rapidproduction.org/de/produkt-kategorie/3d-drucker/)

BESCHREIBUNG

Beschreibung

- Druckbereich 450x450x600 mm^3
- Schichthöhen von 0,05 bis 0,3 mm
- wassergekühltes Hotend (Temperaturen bis 400°C)
- separate Steuerung:
  - mit 18,5 Zoll Monitor,
  - Bluetooth Tastatur
  - Windows und Simplify3d vorinstalliert
- beheizbarer Bauraum

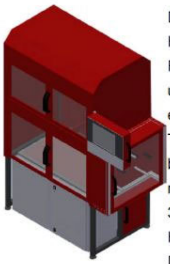
Fabru GmbH 3d printing solutions: "Plastjet 3C-855"

http://www.fabru.eu/index.php/de/produkte/item/plastjet-3c-2

Date Accessed: 13.07.2017

Plastjet 3C-855

Beschreibung



Die PlastJet 3C kombiniert die drei Herstellungsverfahren Fräsen, Fused Deposition Modeling (FDM) und Fabru Plastic Printing(FPP) in einer Maschine. Egal ob Sie Ihre Teile fräsen wollen oder ganz bequem mittels 3D-Druck fertigen möchten, bietet Ihnen die Plastjet 3C immer das passende Herstellungsverfahren.
Die Maschine wird über einen intuitiven und hochwertigen 15" Touchscreen bedient.
Alle Achsen sind mit hochwertigen Kugelumlaufspindeln und hochpräzisen Servomotoren ausgestattet. Dadurch werden hohe Wiederholgenauigkeiten und schnelle Verfahrgeschwindigkeiten bis zu 900mm/s realisiert.
Der auf bis zu 200°C beheizbare Drucktisch erleichtert das Drucken und erhöht die Qualität der Bauteile.
Alle unsere Maschinen werden in der Schweiz hergestellt und sind somit Swiss Made.

News

Die neue Plastjet 3C-855 BASIC erleichtert Ihnen den Einstieg in die Welt des 3D-Druckens.

Specifications

Technische Daten:

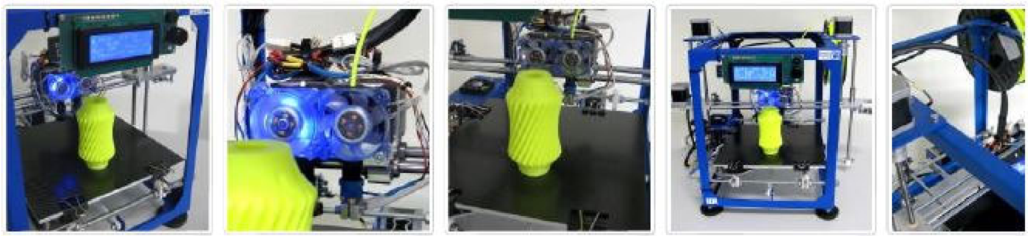
Abmessungen (Länge x Breite x Höhe) mm	1200 x 780 x 2000
Arbeitsbereich (X, Y, Z) mm	816.5 x 510 x 510
Druck-/Verfahrgeschwindigkeit X, Y, Z max. mm/s	900
Verarbeitungstemperatur max. °C (FDM/FPP)	450
Drucktischtemperatur max. °C	200
Düsendurchmesser (FDM/FPP) mm	0.2, 0.3, 0.4, 0.5, 0.6
Materialien FDM	ABS PLA HIPS PA/Nylon PETG ASA PMMA TPE POM PC PVA PEEK PEI

German RepRap GmbH: "Protos 3D Drucker"
https://www.germanreprap.com/produkte/3d-drucker/protos/
Date Accessed: 13.07.2017

PRotos 3D Drucker

Der PRotos v3 ist ein 3D Drucker Bausatz für anspruchsvolle Privatnutzer, Schulen und Unternehmen. Mit einem Druckraum von 205 x 210 x 140 mm lassen sich größere Gegenstände genau und schnell drucken, z.B. Ersatzteile, Spielzeug, Dekorationsartikel, Teile für den Modellbau, Prototypen, etc.

Der PRotos v3 ist ein solider, stabiler und präziser 3D-Drucker zum selbst aufbauen. Damit ist der Protos die günstige aber hochqualitative Wahl für alle, die sich mit dem 3D Drucken tiefer auseinandersetzen und ihren Drucker individuell zusammenstellen und erweitern möchten.



3D Drucker   Bausatz Vergleich   Technische Daten   Upgrade & Zubehör   Service

Druckraum* (XxYxZ)	205 x 210 x 140 mm
Druckgeschwindigkeit	10 – 150 mm/s
Verfahrgeschwindigkeit	10 – 300 mm/s
Positioniergenauigkeit (X/Y)	+/- 0,1 mm
Schichtdicke (minimal)	0,1 mm
Filament / Düsen-Durchmesser (Standard)	3 mm / 0,5 mm
Material*	PLA, ABS, PS, PVA, PP, Laywood, Laybrick, Carbon20
Extrudertyp	DD2 single, dual²*
Extrudertemperatur (max)	265° C
Druckbett-Technologie	unbeheizt, beheizbar¹*
File transfer	LC-Display mit SD-Kartenleser, USB
Software-Ausstattung	Repetier, Slic3r
Leistungsaufnahme (max)	50 W
Betriebsspannung*	115 / 230 V
Außenmaße ca. (BxTxH)	550 x 510 x 425 mm
Gewicht ca.	10,5 kg
Kennzeichnung	DIN EN 12100-1
Optionen	PrintBox, Simplify3D Software

German RepRap GmbH: "X1000 3D Drucker - Industrieller 3D Drucker mit großem Druckraum"

https://www.germanreprap.com/produkte/3d-drucker/x1000/

Date Accessed: 13.07.2017

German RepRap

Ihre Suche Suchen

TECHNIK SUPPORT HOTLINE
+49 9001 737727*
10.00 - 16.00 Uhr MEZ *0,99€/Minute aus dem dt. Festnetz, abweichende Gebühren aus Mobilfunknetzen & Ausland

Sie befinden sich hier: You are here: **German RepRap GmbH > Produkte > 3D Drucker > X1000 3D Drucker**

X1000 3D Drucker

Industrieller 3D Drucker mit großem Druckraum

Der X1000 3D-Drucker druckt große Objekte oder mehrere kleine Objekte in Industriequalität – ob Prototyping, Kleinserienfertigung, Formenbau, Design oder Architektur.

- Großer Druckraum 1000 x 800 x 600 mm (X/Y/Z)
- Hohe Prozesssicherheit
- Viele Sicherheitsfunktionen für industriellen Einsatz
- spezielles Lüftungssystem für Qualitätsdruck
- Netzwerkfähigkeit (WLAN, Ethernet)
- Draft-Mode
- Simplify3D Software im Lieferumfang enthalten

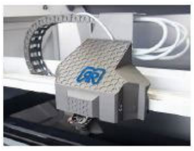
Industrie-Qualität zu fertigen. Individuelle Parameter Einstellungen, die an die Objekt Geometrie angepasst werden können, erlauben die volle Kontrolle über den Druck-Prozess. Dabei ermöglicht die Software die Verwendung von Dual Extrudern, zum Drucken von unterschiedlichen Materialien und Farben sowie die mehrfache Platzierung verschiedener Objekte im Druckraum. Ebenso können verschiedene Bereiche eines einzelnen Bauteils definiert und mit unterschiedlichen Parametern gedruckt werden.

SIMPLIFY3D

Schnelligkeit und hohe Genauigkeit:
Mit 0,1 minimaler Schichtdicke druckt der X1000 sauber und präzise.

Ausgefeilte Easy-to-use Drucksoftware:
Einfach zu bedienende Software mit voreingestellten Druckprofilen für eine schnelle Inbetriebnahme. Viele Funktionen wie z.B. manuelle Stützmaterialplatzierung, Druckvorschau, etc.

Direct Drive DD3 Extruder mit Full-Metal-Hotend:
Neue Antriebstechnologie, kein Nachjustieren mehr nötig, Anpressdruck variierbar. Das Hotend ist bis zu 290°C erhitzbar. Schneller und einfacher Düsenwechsel.



Filament-Management:
Eine Zwei-Punkt-Sensorik verhindert fehlerhafte Drucke durch fehlende Materialzufuhr.

Filetransfer:
Netzwerkfähig über Ethernet und WLAN.

Notwendige Sicherheitsfunktionen für industriellen Einsatz:
Ein geschlossener Schaltschrank, ein Not-Aus-Schalter plus einer optionalen CO2-basierten 2-fach Brandschutzanlage dienen den Anforderungen an einen sicheren Betrieb in industriellen Umgebungen.

Vor-Ort-Service:
Der X1000 ist wartungsfreundlich konzipiert. Zudem bieten wir einen Vor-Ort-Service für Wartung und Installation.

Massivit 3D Printing technologies Ltd.: "Massivit 1800"
http://massivit3d.com/pdf/pdf1.pdf
Date Accessed: 13.07.2017

Massivit 1800

Add a profitable new dimension to your business

Win new business, retain existing clients and distinguish your firm by making super-size 3D displays, prototypes and end-use parts a profitable part of your service offering.

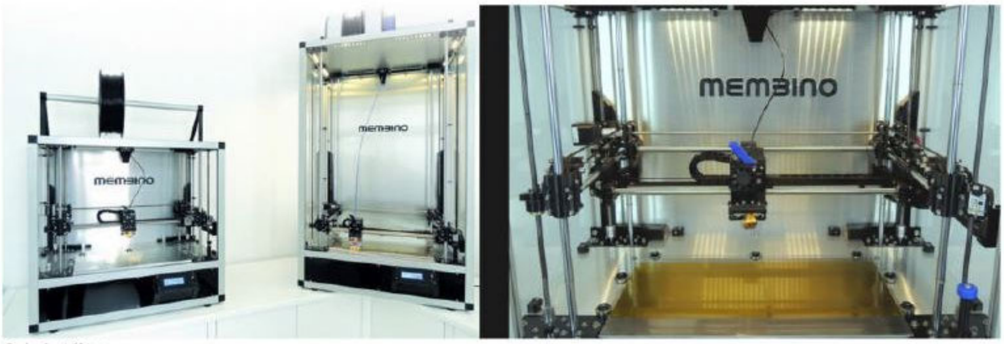
Technical details

Print volume	• WxDxH: 1.17x1.5x1.8m | 46x59x70.86in • Max. object weight 150kg | 330lb
Productivity (z-axis)	Up to 35cm/hr | 13.7in/hr
Printing material	Dimengel - Massivit proprietary photo polymeric printing material white shade pails of 19kg | 41.8lb
Workflow & software	• Software on machine: Massivit proprietary front end software ◦ Operating on Windows* ◦ Network: LAN connection • Massivit Smart: Massivit proprietary software* for file preparation ◦ Features: scale, rotate, slice, support generation ◦ Input file format: STL
Dimensions	Printer WxDxH: 3.1x2.2x2.8m, 10.2x7.3x9.2ft | 2500kg, 5511lb Crated WxDxH: 3.5x2.3x2.6m, 10.9x7.6x8.4ft | 3000kg, 6613lb
Regulatory compliance	CE
Operation requirements**	• Electrical voltage: 3x32A 380-400VAC±10%, 50/60Hz • Power consumption @50Hz (printing): 10kW • Air pressure 6-8 bar | 88-118 psi • Ventilation
Operating environment	• Temperature: 16° to 30°C | 60.8° to 86°F

* Computer not included
** Subject to detailed site preparation guide

Membino GmbH: "Membino 654 Pro"
https://www.membino.de/info/index.php/de/3d-drucker/membino-654-pro
Date Accessed: 13.07.2017

Home | 3D-Drucker | 3D-Druckservice | News | Unternehmen



Galerie öffnen

Standard-Modelle

- Membino Pro Serie
- Modellvergleich
- Membino 423 Pro
- Membino 423 Pro twin
- Membino 543 Pro
- Membino 543 Pro twin
- Membino 654 Pro
- Membino 654 Pro twin
- Membino 864 Pro
- Membino 864 Pro twin
- Druckverfahren FFF

Bauraumhöhen nach Kundenwunsch

Unser Maschinenkonzept erlaubt Bauräume bis zu 800mm x 600mm x 700mm.

Der Bauraum kann, ausgehend von den Standard-Modellen, in Schritten von 100mm auf bis zu 700mm erhöht werden.

Sprechen Sie uns an – wir freuen uns auf Ihre Anfrage!

Spezifikation Membino 654 Pro

Modell	Membino 543 Pro
Abmessungen B x T x H	940mm x 780mm x 880mm ohne Füße, Filamentträger, Display
Fertigungsraum netto X x Y x Z	595mm x 500mm x 400mm
Druckköpfe	1
Gewicht	ca. 66kg
Leistungsaufnahme Druckwerk	angehalten ca. 30W in Betrieb ca. 180W
Leistungsaufnahme Druckbett (max.)	ca. 2200W wird nur in der Aufheizphase erreicht
Leistungsaufnahme im Betrieb (typ.)	ca. 400W

Spezifikation Membino-Pro-Serie

Leasing oder Kauf ?

Sie möchten nicht kaufen ?

Unsere 3D-Drucker können Sie auch zu interessanten Konditionen leasen !

Kontaktieren Sie uns !

Kontakt und Beratung

+49 - 4121 - 7999 431

info@membino.de

Membino GmbH
Vormstegen 25
D-25336 Elmshorn

+49 - 321 - 2118 5371

Newsletter abonnieren

Membino GmbH: "Membino 864 Pro"
https://www.membino.de/info/index.php/de/3d-drucker/membino-864-pro
Date Accessed: 13.07.2017

Home | 3D-Drucker | 3D-Druckservice | News | Unternehmen

Galerie öffnen

Standard-Modelle

- Membino Pro Serie
- Modellvergleich
- Membino 423 Pro
- Membino 423 Pro twin
- Membino 543 Pro
- Membino 543 Pro twin
- Membino 654 Pro
- Membino 654 Pro twin
- Membino 864 Pro
- Membino 864 Pro twin
- Druckverfahren FFF

Bauraumhöhen nach Kundenwunsch

Unser Maschinenkonzept erlaubt Bauräume bis zu 800mm x 600mm x 700mm.

Der Bauraum kann, ausgehend von den Standard-Modellen, in Schritten von 100mm auf bis zu 700mm erhöht werden.

Sprechen Sie uns an – wir freuen uns auf Ihre Anfrage!

Spezifikation Membino 864 Pro

Modell	Membino 864 Pro
Abmessungen B x T x H	1140mm x 880mm x 880mm ohne Füße, Filamentträger, Display
Fertigungsraum netto X x Y x Z	795mm x 600mm x 400mm
Druckköpfe	1
Gewicht	ca. 103kg
Leistungsaufnahme Druckwerk	angehalten ca. 20W in Betrieb ca. 190W
Leistungsaufnahme Druckbett (max.)	ca. 3400W wird nur in der Aufheizphase erreicht
Leistungsaufnahme im Betrieb (typ.)	ca. 520W

Spezifikation Membino-Pro-Serie

Druckverfahren	Fused Filament Fabrica

Leasing oder Kauf ?

Sie möchten nicht kaufen ?

Unsere 3D-Drucker können Sie auch zu interessanten Konditionen leasen !

Kontaktieren Sie uns !

Kontakt und Beratung

+49 - 4121 - 7999 431

info@membino.de

Membino GmbH
Vormstegen 25
D-25336 Elmshorn

+49 - 321 - 2118 5371

Newsletter abonnieren

multec GmbH: "Multirap M800 Industrie-3DDrucker"
https://www.multec.de/3D-Drucker-Multirap-M800
Date Accessed: 13.07.2017

Multirap M800 Industrie-3DDrucker

Artikelnummer: 911-M800

inklusive folgender Komponenten:

Preis auf Anfrage

sofort verfügbar

Beschreibung

Großraumdrucker mit innovativem Mehrfach-Druckkopf
Jetzt zum Messepreis

Industriestandard in Drucktechnologie, Maschinenbau, Antriebstechnik, Sicherheitseinrichtungen und Bedienerfreundlichkeit

Schulungen, Wartungsverträge und Service-Angebote vom Technologie-Experten Multec erhältlich

Maschinenbasis

Solide Konstruktion mit Kugel-Umlauf-Spindeln und schnellen Industrie-Riemenachsen
Sicherheitseinrichtungen entsprechend CE, Maschinenrichtlinie und Produktsicherheitsgesetz selbst-verständlich

Druckkopf Multex2Move

Patentierter, innovativer Druckkopf für schnelle und saubere 3D-Drucke, ermöglicht Dual-Drucke und Druck mit löslichen Stützmaterialien in hervorragender Oberflächengüte.

Technische Daten

Heizbett, geschlossener Druckraum
Filamentmagazin für bis zu 8 Spulen
Industrie-Touchpad 19"
3D-Druck-Software

Druckbereich 650x450x800mm (x/y/z)

Optional kann der M800 mit dem patentierten Druckkopf Multex4Move ausgestattet werden.
Des weiteren ist ein günstigeres Einsteigermodell mit aktuellem Single-Extruder auf Anfrage erhältlich.
Finanzierung und Leasing möglich.

Die Auslieferung erfolgt ab Juli 2017

Titan Robotics: "THE ATLAS"
http://www.titan3drobotics.com/atlas/
Date Accessed: 13.07.2017

THE ATLAS

e Atlas is Titan Robotics' flagship 3-axis industrial 3D printer. The standard build space begins at 30"X x 30"Y x 45"Z, with larger standard models available. Like all of our machines, these imensions are customizable to meet the needs of our clients. The tlas is available as an open air machine or with a custom heated nclosure to allow for printing in high temperature plastics such as ABS and PC+PBT. The Atlas is designed with premium quality electronics and precision components on all axes for maximum speed, accuracy, and reliability.

Custom heated enclosure

BASIC SPECIFICATIONS

Printer Type	FFF (Fused Filament Fabrication)
Standard Build Space	30 x 30 x 45 inches (762 mm x 762 mm x 1143 mm)
Atlas 2.0 Build Space	36 x 36 x 48 inches (915 mm x 915 mm x 1220 mm)
Atlas 2.5 Build Space	42 x 42 x 48 inches (1066 mm x 1066 mm x 1220 mm)
Table Design	Moving, machined aluminum build plate
Frame	Precision machined steel frame (flat tolerance .005")
Components	16mm lead ground recirculating ball screws Size 15mm profiled linear rails and pre-loaded runner blocks
Controller	8GB Smoothieboard 4X or 5X with Reprap Discount Graphic LCD
Software	Simplify 3D (Software settings included)
Servo Speed	Rapid travel up to 1,500 mm/second (Highly recommended)
Heated Bed	110V at 18amps or 220V at 9amps 175°C standard max Vacuum plenum (optional) Auto bed level system
Bed Surface	Polycarbonate or Borosilicate Glass

Titan Robotics: "THE HYPERION"
http://www.titan3drobotics.com/atlas/
Date Accessed: 13.07.2017

THE HYPERION

ıe **Hyperion** is our Core XY based high speed printer with
ˈecision machined components. The base model has a build space
ˈ 24″X x 24″Y x 24″Z. It is fully enclosed and has a heated build
ate. The customizable Bowden extruder is capable of printing
75mm or 3mm plastics of any variant. The machine is capable of
esignated feed rates per axis with a guaranteed repeatability of +-
01″.

The Hyperion

BASIC SPECIFICATIONS

OUR WORK • ABOUT • CONTACT

Printer Type	FFF (Fused Filament Fabrication)
Standard Build Space	24x24x24 inches(45x45x61 inch footprint) Heated sheet metal enclosure Max temperature 85°C
Design	Overhead gantry, CORE XY design
Frame	Precision machined steel frame (flat tolerance .001″)
Components	X and Y axis driven by core XY belt configuration 15mm GT3 belts Z axis driven by 16mm direct drive ballscrew configuration Yaskawa closed loop AC servos (optional upgrade)
Controller	Smoothieboard firmware with Reprap Discount Graphic LCD
Software	Simplify 3D (Software settings included)
Speed	Rapid travel up to 1,500 mm/second
Bed	Heated up to 175°C Machined aluminum build plate Vacuum plenum (optional)

VIII. Digital Appendix

This CD contains all websites as PDF-printouts used for the market potential analysis in chapter three as well as the data files for the market potential analysis and the target group classification from chapter five. Further included are all source websites.

IX. Declaration of Originality

Ich, Florian Kappmeier, versichere, dass ich die vorliegende Arbeit ohne fremde Hilfe verfasst und nur die angegebenen Quellen als Hilfsmittel benutzt habe. Wörtlich oder dem Sinn nach aus anderen Werken entnommene Stellen sind unter Angabe der Quelle kenntlich gemacht.

Erklärung - Einverständnis

Ich erkläre mich damit einverstanden, dass ein Exemplar meiner Bachelor Thesis in die Bibliothek des Fachbereichs aufgenommen wird; Rechte Dritter werden dadurch nicht verletzt.

Hamburg, den 31.08.2017

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Florian Kappmeier