

Technische Hochschule Nürnberg, MIFE Applied Research Project
Supervisor Prof. Dr. Helen Rogers

3D-Spectacles

Research Question

“Does Selective Laser Metal Sintering, an additive manufacturing procedure, have the potential to eventually break-even a start-up company in the industry sector of producing individualized spectacles and lead to a sustainable business model in the long-run?”

Agenda

1. Business Model

2. Market Analysis

3. Technology

4. Production

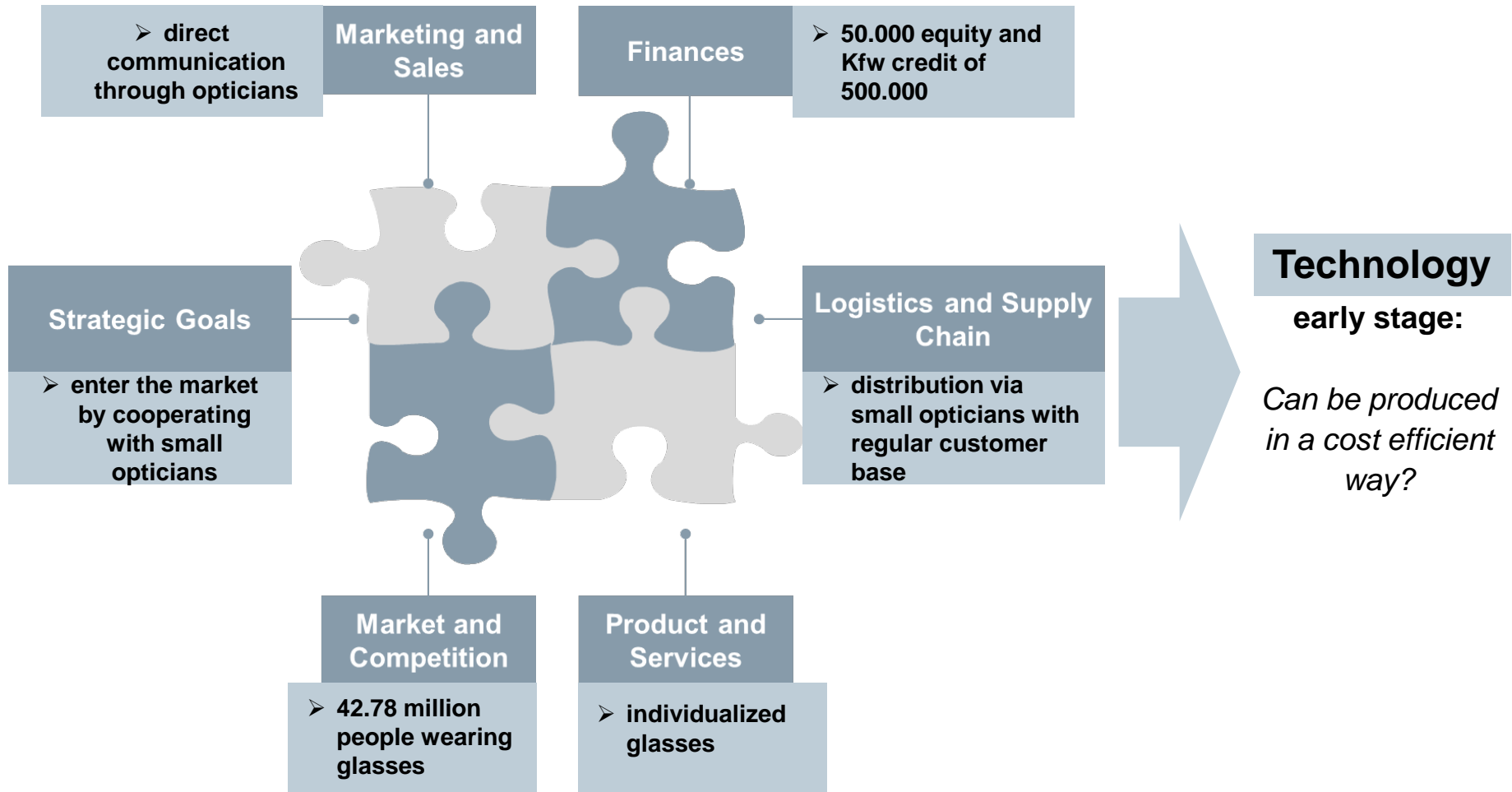
5. Financial Analysis

6. Financing

1. Business Model

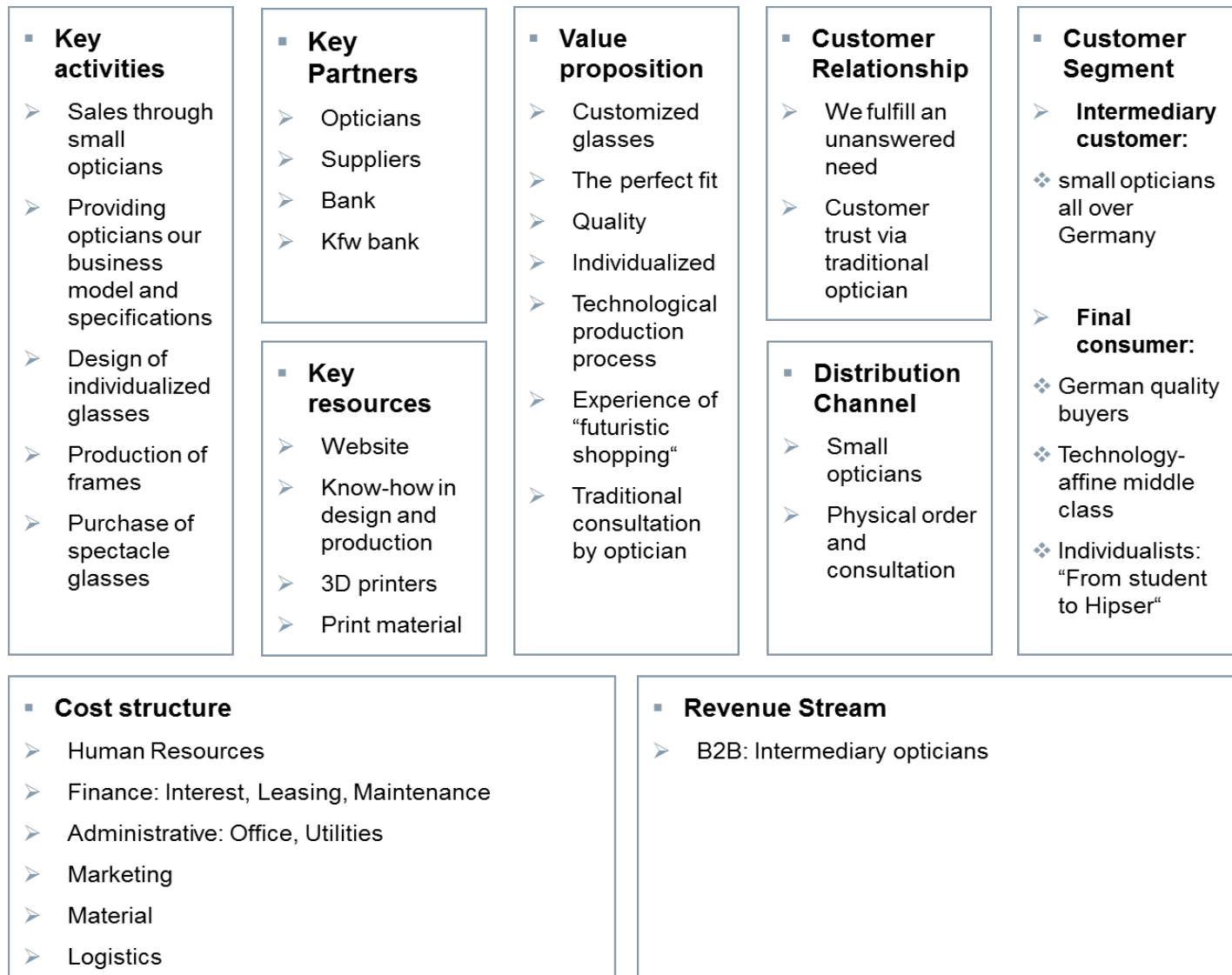
Executive Summary

Business idea: 3D technology applied to manufacturing of customized spectacles for sophisticated clients on demand



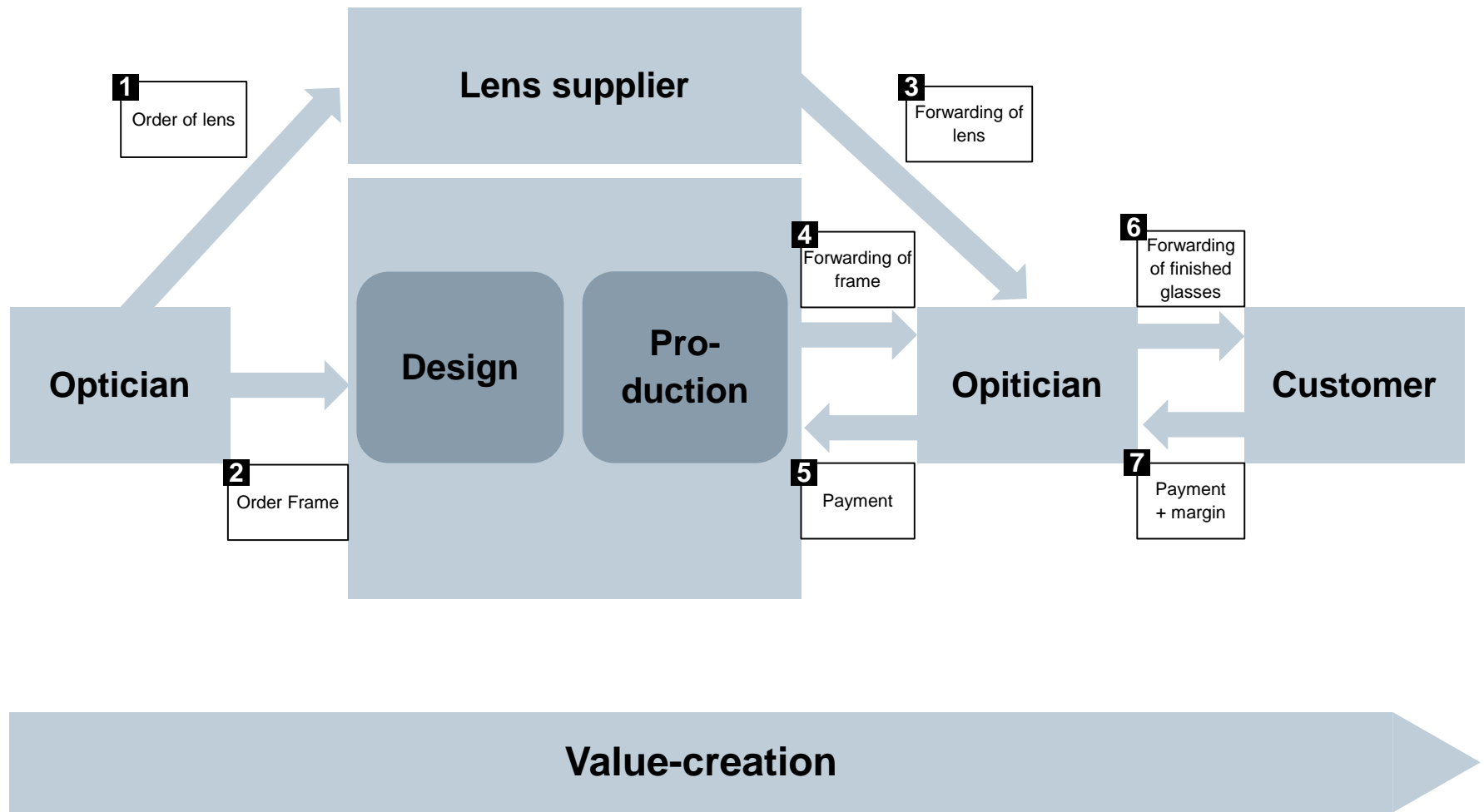
Source: own figure based on template of (Schwetje & Vaseghi, 2007)

1. Business Model Summary



1. Business Model

Supply Chain



2. Market Analysis

The German Spectacles Market

63.5% of German population older than 16 is wearing spectacles

Around 12,000 opticians

- Big chains like Fielmann (65% market share), Apollo and Pro Optik
- many small retailers

Around 11 mn spectacles are sold per year
(number is quite constant!)

Average price per spectacles is at EUR 344

Increasing revenues
(from EUR 4.59 bn in 2007 to EUR 5.63 bn in 2014)

On average Germans buy new spectacles after 2.83 years

Material of frames sold

Metal	54.8%
Plastic	27.6%
Others	17.6%

➤ The German market for spectacles is **huge** and **mature**

Sources: Summary Seven Healthcare Consulting GmbH, 2015; Institut für Demoskopie Allensbach, 2015; Statista, 2015; Zentralverband der deutschen Augenoptiker, 2015

2. Market Analysis

Competitor Analysis – “Old Companies”

	Luxottica	Rodenstock
Country of Origin	Italy	Germany
Sales (2014)	€ 7.6 bn	€ 408 mn
Employees	77,734	4,500
Most Important Brands	Ray-Ban, Oakley, Armani, Chanel, Burberry, Coach	Rodenstock, Jil Sander, Bogner
Active in 3D-Printing	No	No
Important Facts	Largest producer worldwide (cover 80% of world's most important brands)	Also produce lenses and optical devices for measuring

- Luxottica is by far the largest company in the market (worldwide)
- Rodenstock is largest German spectacles-producer and is also active in other fields of business

Sources: Luxottica, 2015; Rodenstock, 2015

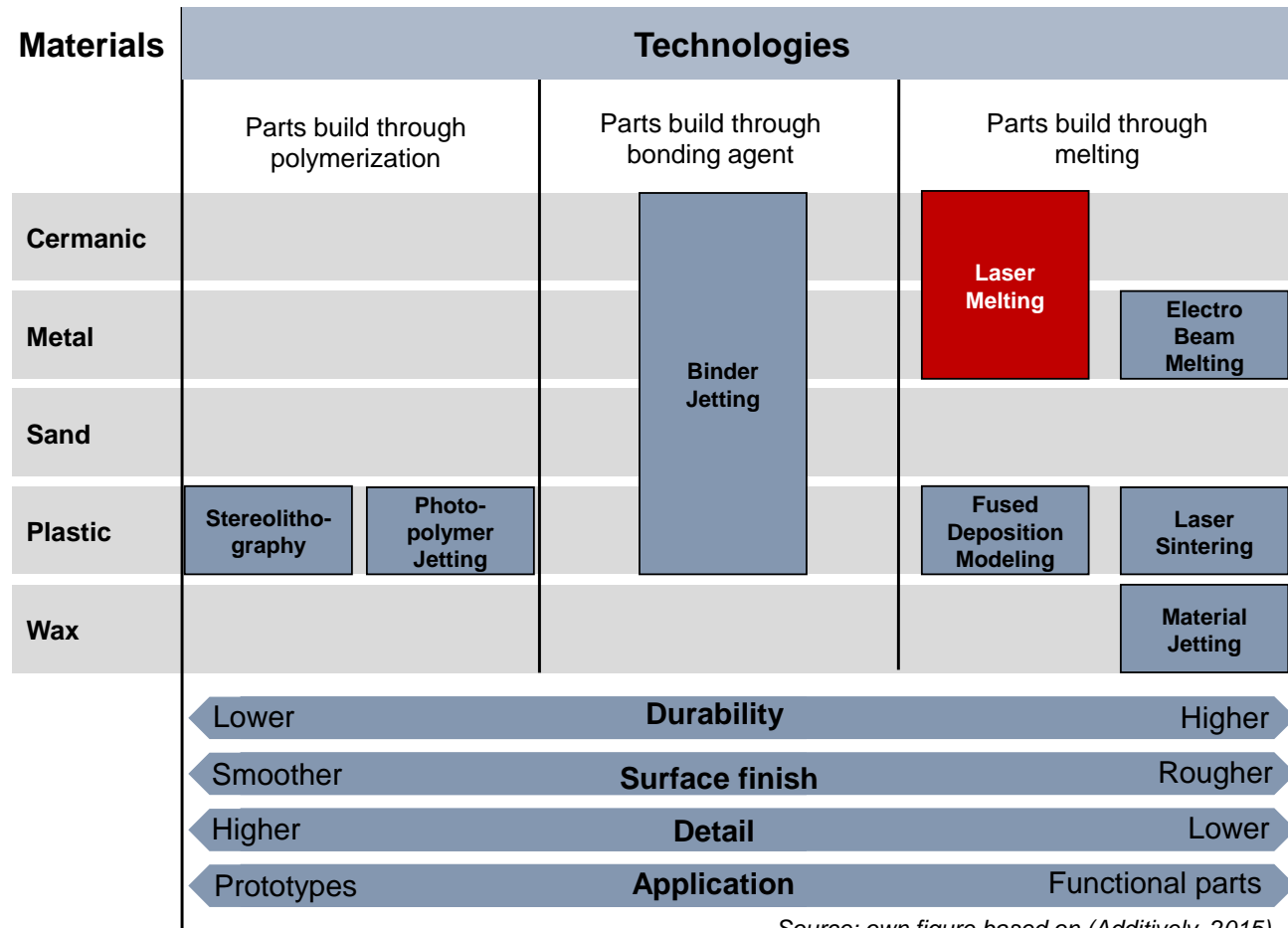
2. Market Analysis

Competitor Analysis – “Young Companies”



3. Technology

Overview of printing technologies and main characteristics



Source: own figure based on (Additively, 2015)

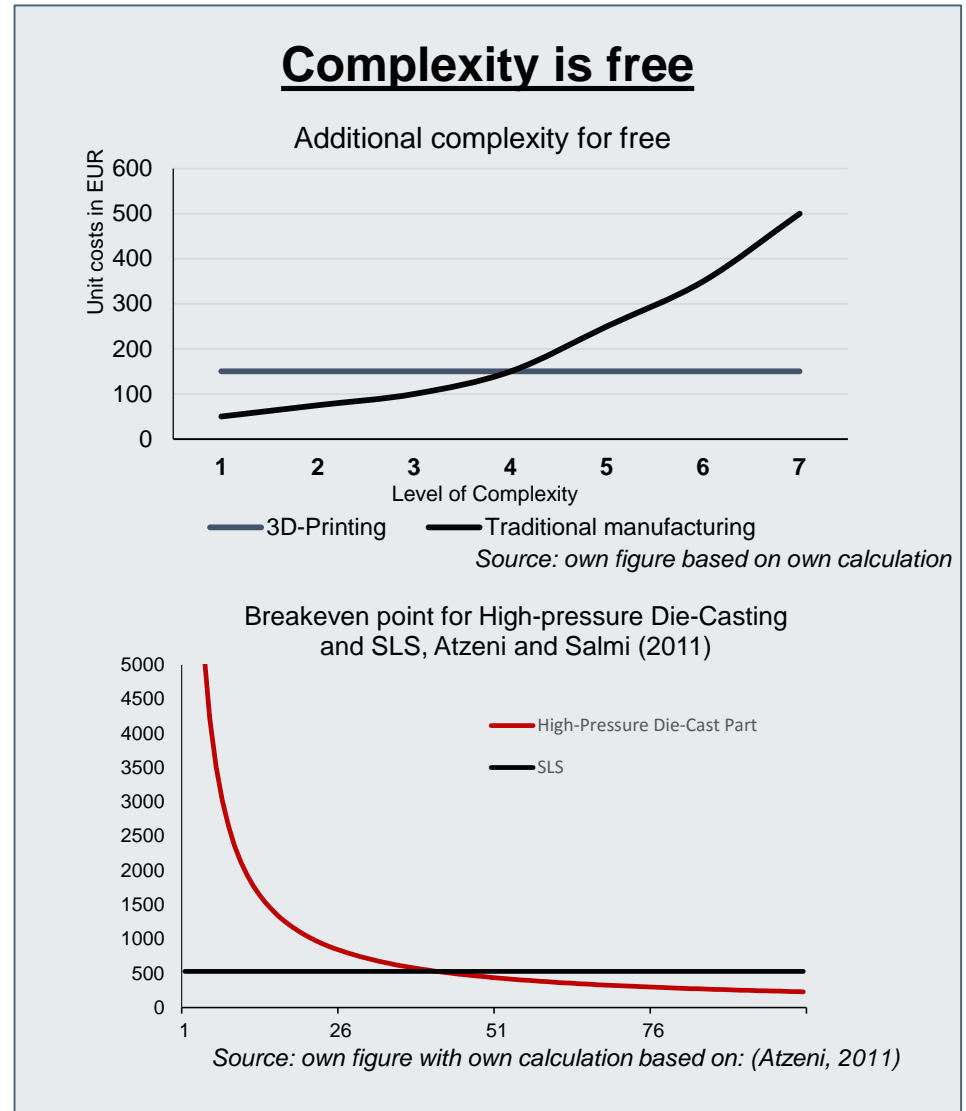
Laser Melting is fulfilling all important prerequisites with respect to **Durability** and **Application**, dictated by our selling preposition

3. Technology

Advantages of 3D-printing

Advantages
Complexity is free
> Additional complexity comes without additional costs
Freedom of design
> Existing designs and new designs are easily changeable or designable with almost no limitations
No assembly required
> Final parts can be printed directly without requiring a post assembly afterwards.
Little lead time
> Designed models can be printed immediately without long waiting times for final part to be arrive
Little-skill manufacturing
> The process of 3D-printing is rather simple allowing also non experts to develop sophisticated products
Elimination of production steps
> The process of 3D-printing is rather simple allowing also non experts to develop sophisticated products
Sophisticated designs
> The technology enables the design of lightweight parts which are impossible to develop in a conventional way

Source: own table based on (Royal Academy of Engineering, 2013), (Azom, 2015)



3. Technology

Manufacturing readiness and the implementation stages

3D-printing primarily designed for prototyping

➤ **Not constraints regarding:**

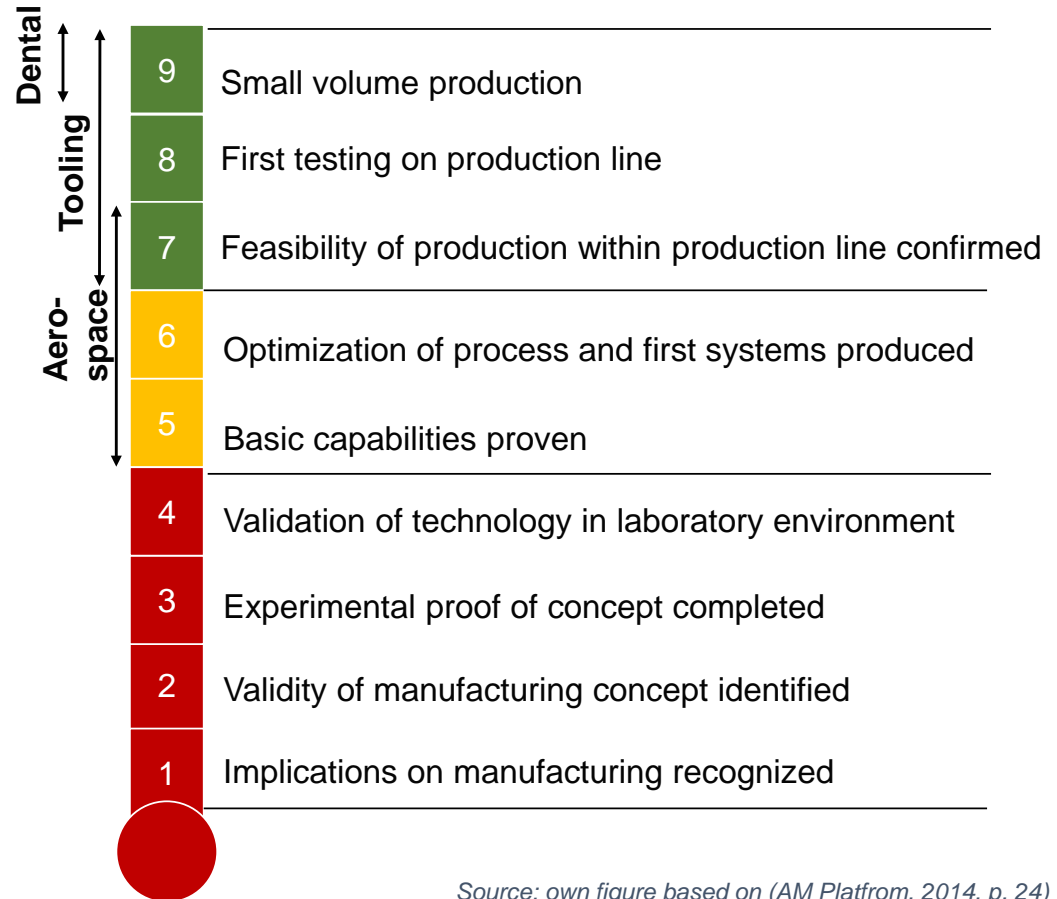
- Building speed
- Material costs

• For prosthetic dentistry and tooling, 3D-printing is currently used for production

• Strong research focus of Aerospace industry & automotive industry

➤ **Still 3D-printing is not designed for huge volume production**

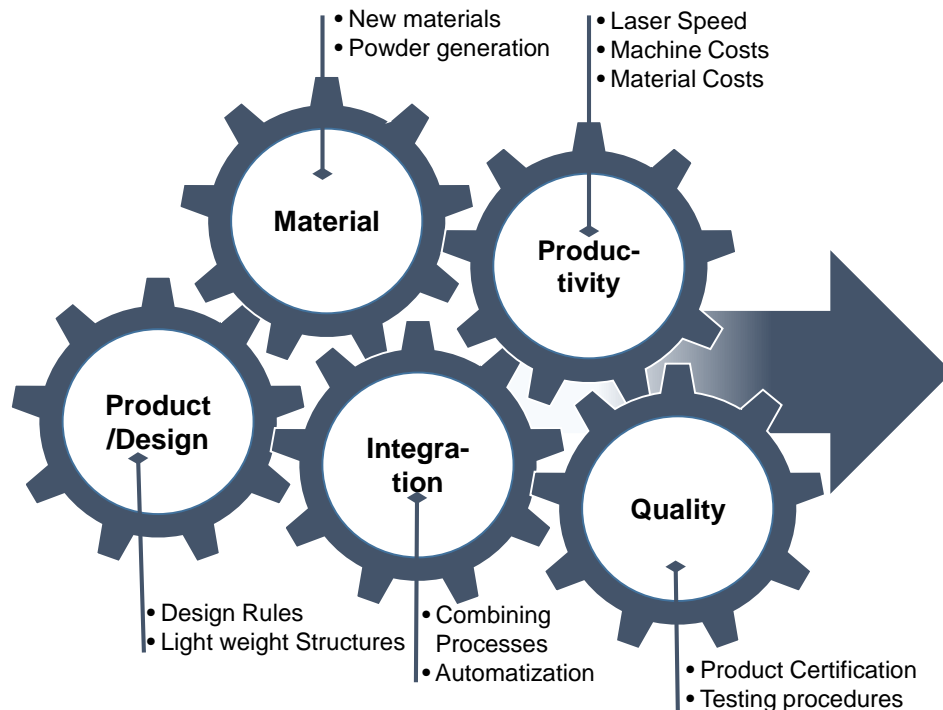
!!! Pioneer role !!!



Source: own figure based on (AM Platform, 2014, p. 24)

3. Technology

The main challenges in the field of additive manufacturing



Source: own figure based on (Gausemeier, Waller, & Peter, 2013, pp. 71-79)

Object Accuracy & Quality:

- Poor surface quality and the corresponding need for post processing

Cost :

- Material prices are not reflecting current production costs (highly overpriced)

Building Speed:

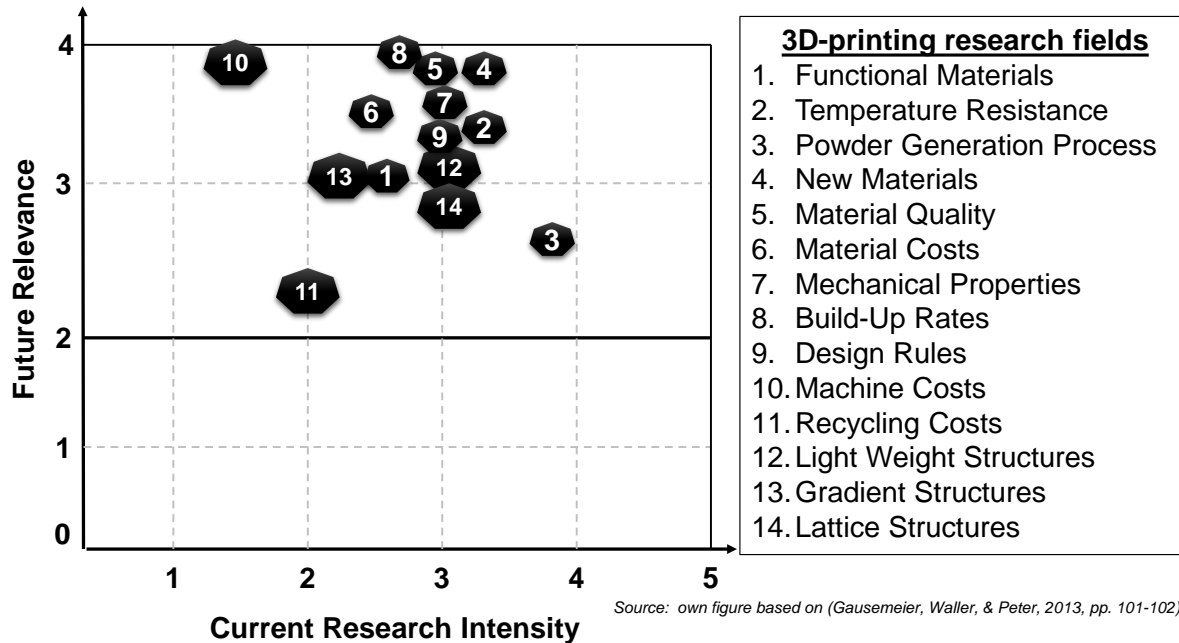
- Considerably slower compared to mass production!

Material Properties:

- Only a small selection of materials compared to divers materials with different functionalities for consumer goods

3. Technology

Current research focus & the consequent derived future trends



Strong research focus in the field of all important challenges

- *Machine Costs* = lowest research focus
- *Powder generation* = highest research focus

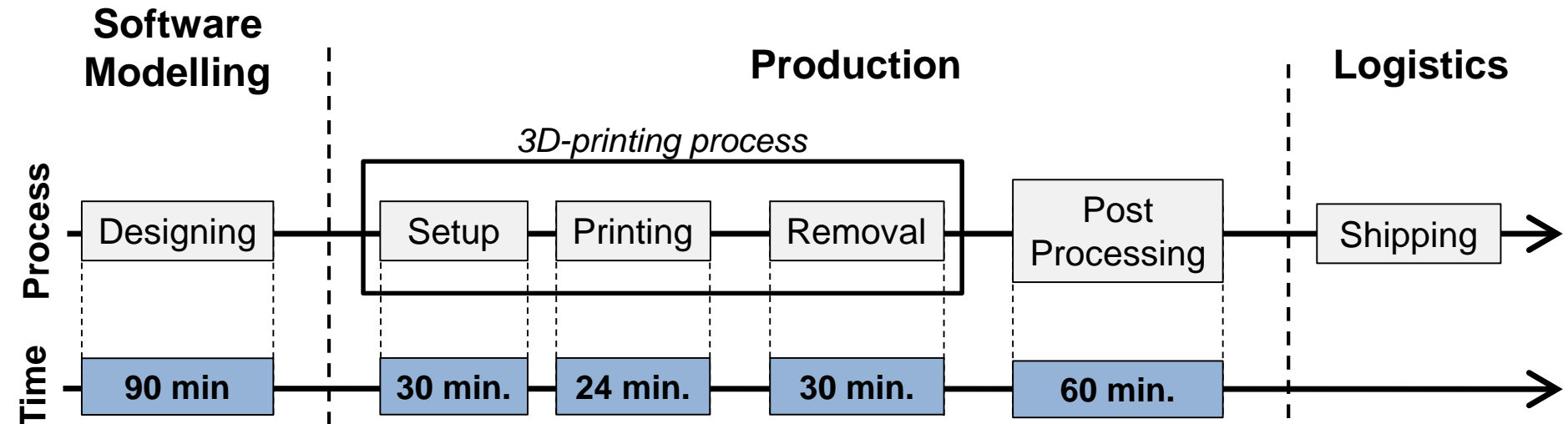
Trends are aligned with current research focus

- Indication of high future potentials
- Attractiveness will increase, due to investments of huge industries
i.e. (*Aerospace, car*)

Parameters	Rationales	Trend
<i>Build Rates</i>	- New innovative production processes (CLIP process) - More efficient layer structure (various layerthicknesses) - More stable production process due to online monitoring - continuous production enabled through more chamber systems	↑
<i>Machine Price</i>	- Machine prices are currently accepted by the customers - Stronger lasers, more chambers, additional control devices will further increase machine costs	↗
<i>Powder Prices</i>	- Current powder prices charged are not reflecting their production costs - Increasing competition will result in lower powder prices in the future	↘
<i>Labor costs</i>	- Monitoring efforts will fall due to more efficient systems	↘
<i>Materials</i>	- New materials will be available in future with different functionalities or behaviours - Mixing of powders will lead to new material properties and functionalities	↗
<i>Quality</i>	- New printing processes will lead to better surface finishing - Fatigue of life will be extenden	↗

4. Production

Overall production process



Source: own figure based on production process

- Overall Production process divided into: *Software modelling, Production and Logistics*
- Printing process itself (setup, printing, removal) needs almost one and a half hour
- Individual printing steps are successive and cannot be executed simultaneously
- Removal includes also maintenance and cooling
- Post processing: Polishing, coloring and correcting unevenness
- Logistics: Packing the glasses into a package and send it to the customer

4. Production

Production time

2015/Year 1	ccm/h
Printer build speed	25
Glass	10
	minutes
Preheat/set up	30
minutes per glass printing	24
Maintenance	13,20
Cooling	15
	minutes
Time in total per glass	82,20
8h production per day	480
Machine utilization	86%
Effective production per day	412,8
	units
Numbers per glass per day	5

	minutes
Designing	90
Post-processing	60
Workload for 1 designer	480
Workload for 1 engineer	480
Capacity designer per day	5
Capacity engineer per day	8

2018/Year 3	ccm/h
Printer build speed	40
Glass	10
	minutes
Preheat/set up	30
minutes per glass printing	15
Maintenance	13,20
Cooling	15
	minutes
Time in total per glass	73,20
8h production per day	480
Machine utilization	86%
Effective production per day	412,8
	units
Numbers per glass per day	5

Source: own figure based on own calculations and assumptions

In year 1:

Printer build speed of 25 ccm/h
5 units per day possible to print

In year 3:

Printer build speed of 40 ccm/h
Still 5 units per day possible to print

4. Production

Production plan

Year	1	2	3	4	5	6	7	8	9	10
Sales Unit	900	1080	1296	1556	1712	1884	2073	2177	2286	2401
Working days	250	250	250	250	250	250	250	250	250	250
Units per day	3,60	4,32	5,18	6,22	6,85	7,54	8,29	8,71	9,14	9,60
Year	1	2	3	4	5	6	7	8	9	10
Printer 1 Units/year	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250
Puffer/Lack 1 printer	350	170	-46	-306	-462	-634	-823	-927	-1036	-1151
Printer needed (rounded)	1	1	2	2	2	2	2	2	2	2
Printer 2 Units/year			1250	1250	1250	1250	1250	1250	1250	1250
Total capacity/year	1250	1250	2500	2500	2500	2500	2500	2500	2500	2500
Puffer/Lack with 2nd printer	350	170	1204	944	788	616	427	323	214	99
Year	1	2	3	4	5	6	7	8	9	10
Units per day	3,6	4,3	5,2	6,2	6,8	7,5	8,3	8,7	9,1	9,6
Designer 1 units per day	5	5	5	5	5	5	5	5	5	5
Puffer/Lack 1 designer	1	1	0	-1	-2	-3	-3	-4	-4	-5
Designers needed	1	1	2	2	2	2	2	2	2	2
Designer 2 Units per day			5	5	5	5	5	5	5	5
Total units per day	5	5	10	10	10	10	10	10	10	10
Puffer/Lack with 2 designers	1	1	5	4	3	2	2	1	1	0
Year	1	2	3	4	5	6	7	8	9	10
Units per day	3,6	4,3	5,2	6,2	6,8	7,5	8,3	8,7	9,1	9,6
Engineer 1 units per day	8	8	8	8	8	8	8	8	8	8
Puffer/Lack 1 engineer	5	4	3	2	2	1	-1	-1	-2	-2
Engineers needed	1	1	1	1	1	1	2	2	2	2
Capacity 2nd engineer							8	8	8	8
Total units per day	8	8	8	8	8	8	16	16	16	16
Puffer/Lack with 2 designers	4	4	3	2	1	0	8	7	7	6

Year 2: Second printer and second designer
Year 7: Second engineer

Source: own figure based on calculations & assumptions

5. Financial Analysis

Cost Overview

Fixed costs	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Personnel costs	500 €	500 €	500 €	60.000 €	62.975 €	66.099 €	69.379 €	72.823 €	76.439 €	80.236 €
Finance Costs	55.000 €	55.000 €	105.750 €	115.750 €	115.750 €	115.750 €	115.750 €	113.969 €	112.188 €	110.406 €
Interests KfW	4.250 €	4.250 €	4.250 €	14.250 €	14.250 €	14.250 €	14.250 €	12.469 €	10.688 €	8.906 €
Leasing	37.250 €	37.250 €	74.500 €	74.500 €	74.500 €	74.500 €	74.500 €	74.500 €	74.500 €	74.500 €
Maintenance	12.000 €	12.000 €	24.000 €	24.000 €	24.000 €	24.000 €	24.000 €	24.000 €	24.000 €	24.000 €
consumables	1.500 €	1.500 €	3.000 €	3.000 €	3.000 €	3.000 €	3.000 €	3.000 €	3.000 €	3.000 €
Administrative	31.730 €	32.513 €	35.579 €	37.002 €	37.943 €	39.525 €	40.542 €	41.589 €	42.668 €	43.779 €
Marketing	20.000 €	20.000 €	20.000 €	20.000 €	20.000 €	20.000 €	20.000 €	20.000 €	20.000 €	20.000 €
Total	107.230 €	108.013 €	161.829 €	232.752 €	236.668 €	241.374 €	245.670 €	248.380 €	251.294 €	254.421 €

Variable costs per unit	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Direct material costs	206,17 €	202,73 €	202,31 €	199,93 €	194,58 €	194,26 €	193,97 €	193,69 €	191,44 €	191,21 €
Indirect material costs	10,87 €	10,91 €	11,11 €	11,23 €	11,35 €	11,53 €	11,47 €	11,59 €	11,71 €	11,83 €
Logistic costs	5,99 €	5,99 €	5,99 €	5,99 €	5,99 €	5,99 €	5,99 €	5,99 €	5,99 €	5,99 €
Total	223 €	220 €	219 €	217 €	212 €	212 €	211 €	211 €	209 €	209 €
Selling Price netto	330,00 €	330,00 €	330,00 €	330,00 €	330,00 €	330,00 €	330,00 €	330,00 €	330,00 €	330,00 €
Contribution ratio	32%	33%	34%	34%	36%	36%	36%	36%	37%	37%
Contribution margin	106,96 €	110,38 €	110,59 €	112,85 €	118,08 €	118,22 €	118,57 €	118,73 €	120,86 €	120,97 €

- Fixed cost mainly driven by HR and new machine leasing in year 3 & 4, which is analyzed in production plan.
- Variable cost is over 90% due to the lens, and we forecast an stable increase in rent and utility fee, and a stable decrease in direct material and lens cost with an increasing purchase amount.
- Sales price is prudently set at fixed 330 Euro, and forecast an increasing of contribution rate due to the learning curve and decrease in variable cost.

5. Financial Analysis

P&L Overview

P&L	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Sales	297.000	356.400	427.680	516.047	570.624	631.093	697.875	736.551	777.296	820.481
COGS	195.343	230.721	276.596	428.484	467.987	521.088	579.963	616.819	651.754	694.115
Gross Profit	101.657	125.679	151.084	87.563	102.637	110.004	117.912	119.731	125.542	126.366
Selling Exp.	20.006	20.006	20.006	20.006	20.006	20.006	20.006	20.006	20.006	20.006
Administration	31.730	32.513	35.579	37.002	37.943	39.525	40.542	41.589	42.668	43.779
Other Op.	13.500	13.500	27.000	27.000	27.000	27.000	27.000	27.000	27.000	27.000
Depreciation	30.192	12.192	12.192	1.025	1.025	1.025	1.025	1.025	1.025	1.025
EBIT	6.229	47.468	56.307	2.530	16.663	22.448	29.339	30.111	34.843	34.556
Interest Exp.	4.250	4.250	4.250	14.250	14.250	14.250	14.250	12.469	10.688	8.906
Leasing Exp.	37.250	37.250	74.500	74.500	74.500	74.500	74.500	74.500	74.500	74.500
EBT	- 35.271	5.968	- 22.443	- 86.220	- 72.087	- 66.302	- 59.411	- 56.857	- 50.344	- 48.850
Taxes 30%	- 10.581	- 8.791	- 6.733	- 32.599	- 54.225	- 74.116	- 91.939	-108.996	-124.099	-138.754
Earnings	- 35.271	14.759	- 22.443	- 86.220	- 72.087	- 66.302	- 59.411	- 56.857	- 50.344	- 48.850

- Due to new machine leasing and salary to co-founders in year 3 & 4 , company begins to make continuous loss.
- the overall accumulated loss for the first 10 years amounted to around 0.5 Million Euro.
- The first four years interest rate for Kfw is 0,85% and 2,85% onwards, and company starts to pay back principal starting from years 8.

5. Financial Analysis

Balance Sheet Overview

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Fixed Assets	40.250 €	29.225 €	18.200 €	7.175 €	6.150 €	5.125 €	4.100 €	3.075 €	2.050 €	1.025 €
Equipment	30.000 €	20.000 €	10.000 €	- €	- €	- €	- €	- €	- €	- €
Intangible Assets	10.250 €	9.225 €	8.200 €	7.175 €	6.150 €	5.125 €	4.100 €	3.075 €	2.050 €	1.025 €
Current Assets	511.382 €	489.866 €	519.196 €	511.786 €	428.413 €	360.073 €	297.789 €	178.549 €	61.561 €	48.457 €
Cash	300.328 €	261.926 €	246.203 €	187.729 €	81.025 €	21.610 €	121.571 €	261.257 €	395.121 €	527.560 €
Inventories	180.000 €	212.760 €	255.312 €	303.420 €	325.280 €	357.960 €	393.870 €	413.630 €	429.768 €	451.388 €
Supplies	13.054 €	15.180 €	17.681 €	20.637 €	22.108 €	23.723 €	25.490 €	26.176 €	26.914 €	27.715 €
Low-value Assets	18.000 €	- €	- €	- €	- €	- €	- €	- €	- €	- €
Office Equipment	3.500 €	2.333 €	1.167 €	- €	- €	- €	- €	- €	- €	- €
Total Assets	551.632 €	519.091 €	537.396 €	518.961 €	434.563 €	365.198 €	301.889 €	181.624 €	63.611 €	47.432 €
Equity	36.617 €	1.346 €	16.105 €	- 6.338 €	- 92.558 €	- 164.645 €	- 230.947 €	- 290.358 €	- 347.215 €	- 397.560 €
Equity contribution	50.000 €	36.617 €	1.346 €	16.105 €	- 6.338 €	- 92.558 €	- 164.645 €	- 230.947 €	- 290.358 €	- 347.215 €
Retained earnings	- 13.383 €	- 35.271 €	14.759 €	- 22.443 €	- 86.220 €	- 72.087 €	- 66.302 €	- 59.411 €	- 56.857 €	- 50.344 €
Long-Term Debt	500.000 €	500.000 €	500.000 €	500.000 €	500.000 €	500.000 €	500.000 €	437.500 €	375.000 €	312.500 €
Notes Payable	500.000 €	500.000 €	500.000 €	500.000 €	500.000 €	500.000 €	500.000 €	437.500 €	375.000 €	312.500 €
Current Liabilities	15.015 €	17.745 €	21.290 €	25.299 €	27.120 €	29.843 €	32.836 €	34.482 €	35.827 €	37.628 €
Accounts Payable	15.015 €	17.745 €	21.290 €	25.299 €	27.120 €	29.843 €	32.836 €	34.482 €	35.827 €	37.628 €
Total Liabilities	551.632 €	519.091 €	537.396 €	518.961 €	434.563 €	365.198 €	301.889 €	181.624 €	63.611 €	47.432 €

- Company Assets side mainly made up of cash and production inventories, Liability side of equity injection and long term loan from Kfw.
- Starting from year 4 , company will anticipate a negative equity balance.

6. Financing

Cash-Flow Statement and the NPV

Cash-Flow Statement	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9
Net Profit	- €	35.271 €	14.759 €	22.443 €	86.220 €	72.087 €	66.302 €	59.411 €	56.857 €	50.344 €
+ Depreciation		30.192 €	12.192 €	12.192 €	1.025 €	1.025 €	1.025 €	1.025 €	1.025 €	1.025 €
+/- Δ Working Capital	- 178.039 €	34.598 €	43.949 €	49.497 €	25.784 €	35.847 €	38.959 €	23.075 €	19.272 €	23.826 €
+/- Δ Financing	550.000 €	- €	- €	- €	- €	- €	- €	62.500 €	62.500 €	62.500 €
+ Taxshield	- €	1.275 €	1.275 €	1.275 €	4.275 €	4.275 €	4.275 €	4.275 €	3.741 €	3.206 €
- one-time expenses	- 71.633 €	- €	- €	- €	- €	- €	- €	- €	- €	- €
Cash-Flow	300.328 €	38.402 €	15.723 €	58.474 €	106.705 €	102.635 €	99.961 €	139.686 €	133.864 €	132.439 €

$$NPV = \sum_{t=1}^T \frac{C_t}{(1+r)^t} - C_0 \quad \xrightarrow{\text{BUT}} \quad C_t = \text{negativ} \quad \xrightarrow{\text{Therefore}} \quad NPV = \text{negativ}$$

The Cash-Flow Statement shows **negative Cash-Flows** over the next 10 years.

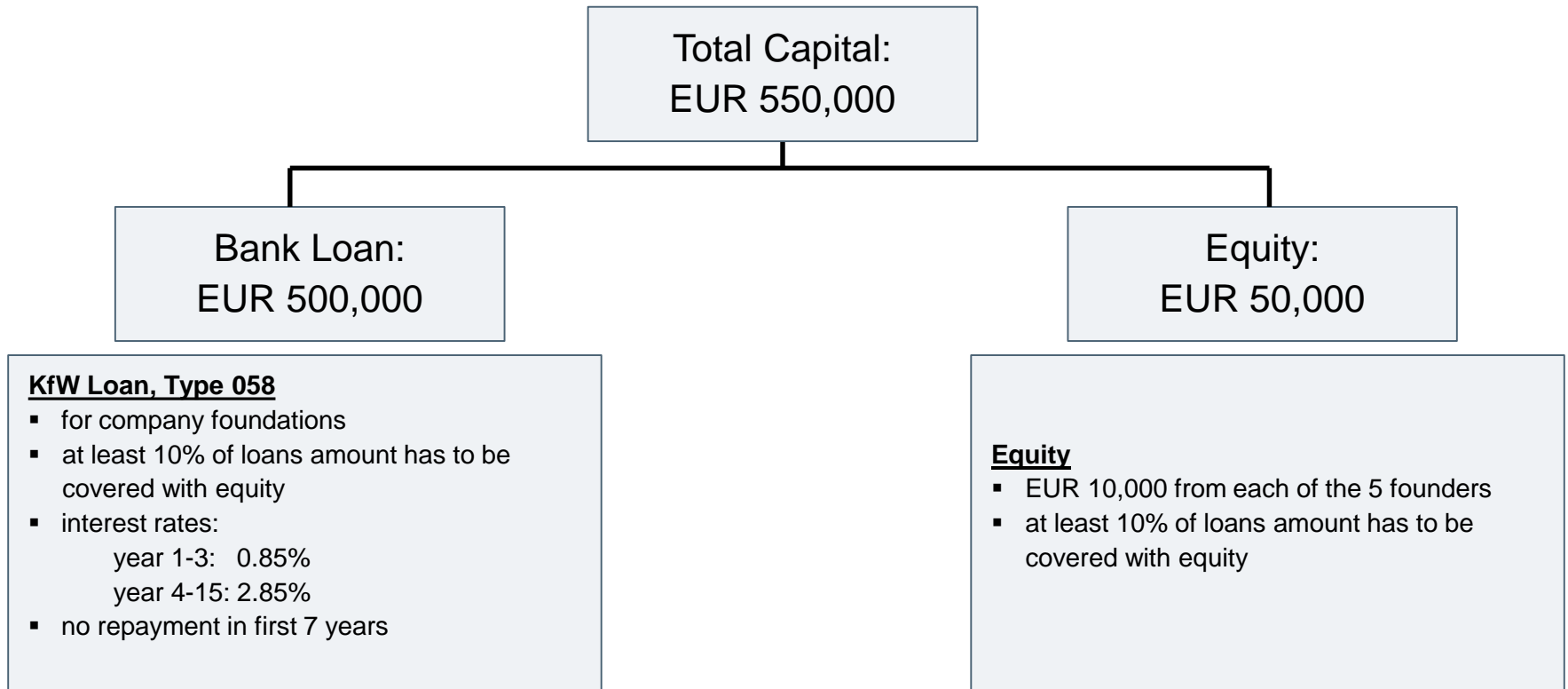
➤ Trend along with the P&L, except for the significant credit repayments starting in year 7

Therefore: Debt financing via bank loan difficult!

Conclusion: Funding via KfW loan (Type 058)

6. Financing

Funding by KfW Loan (Type 058)



Sources: KfW, 2015

Research Hypothesis - refuted

Refuted!

“The additive manufacturing procedure Selective Laser Metal Sintering does, based on the status quo technology and production costs, not have the potential to break-even a start-up company in the production of individualized glasses. There is no chance to create a sustainable business model with the realistically available financing possibilities, not even in the long-run.”