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Evaluation of Cost Structures of Additive Manufacturing Processes Using a New Business Model

by

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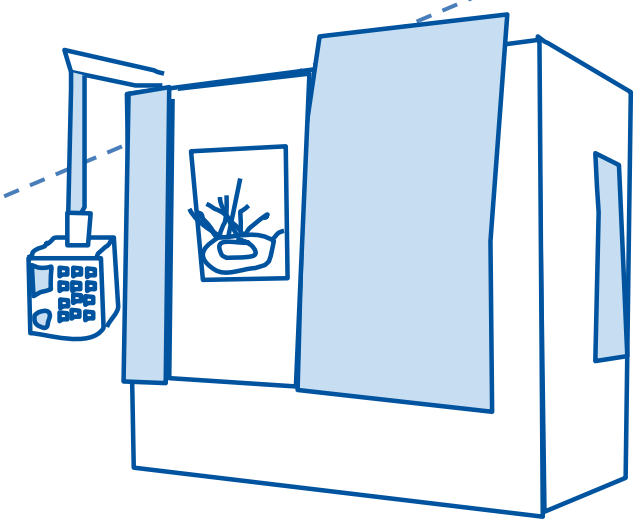
Research idea

→ Extension of PSS trough an integration of *business process* support

→ In the case of additive manufacturing technologies



- Cost calculation
- Investment assessment
- Process optimization
- …

- Maintenance
- Materials
- Machine setting
- …

- Maintenance
- Materials
- Process optimization
- …

Machine focus

Business process focus

Problem statement

"Additive manufacturing technologies are enabler for individualized products"

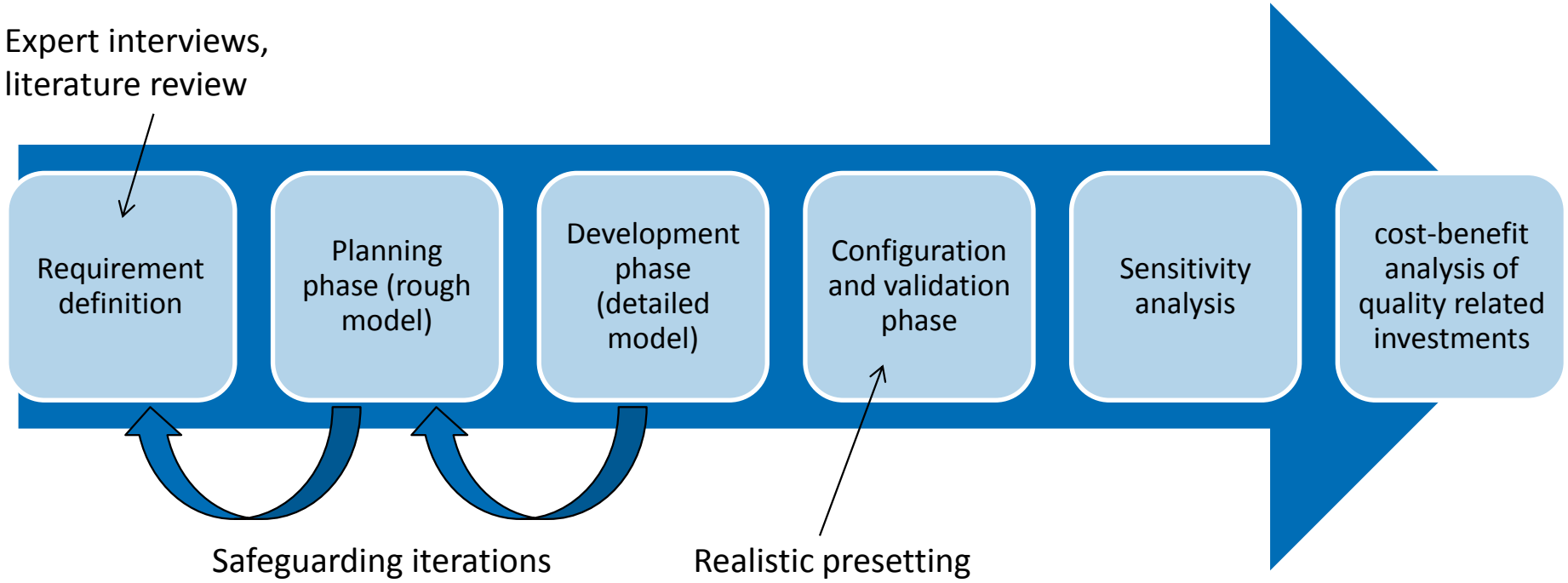
- Complex geometries
- Lightweight construction
- Wide range of materials
- High material utilization
- …

- Need for an appropriate process model for cost calculations
- Optimization of production costs
- Assessment of investments in the hole additive manufacturing process
- Management decision support

"Complex calculations"

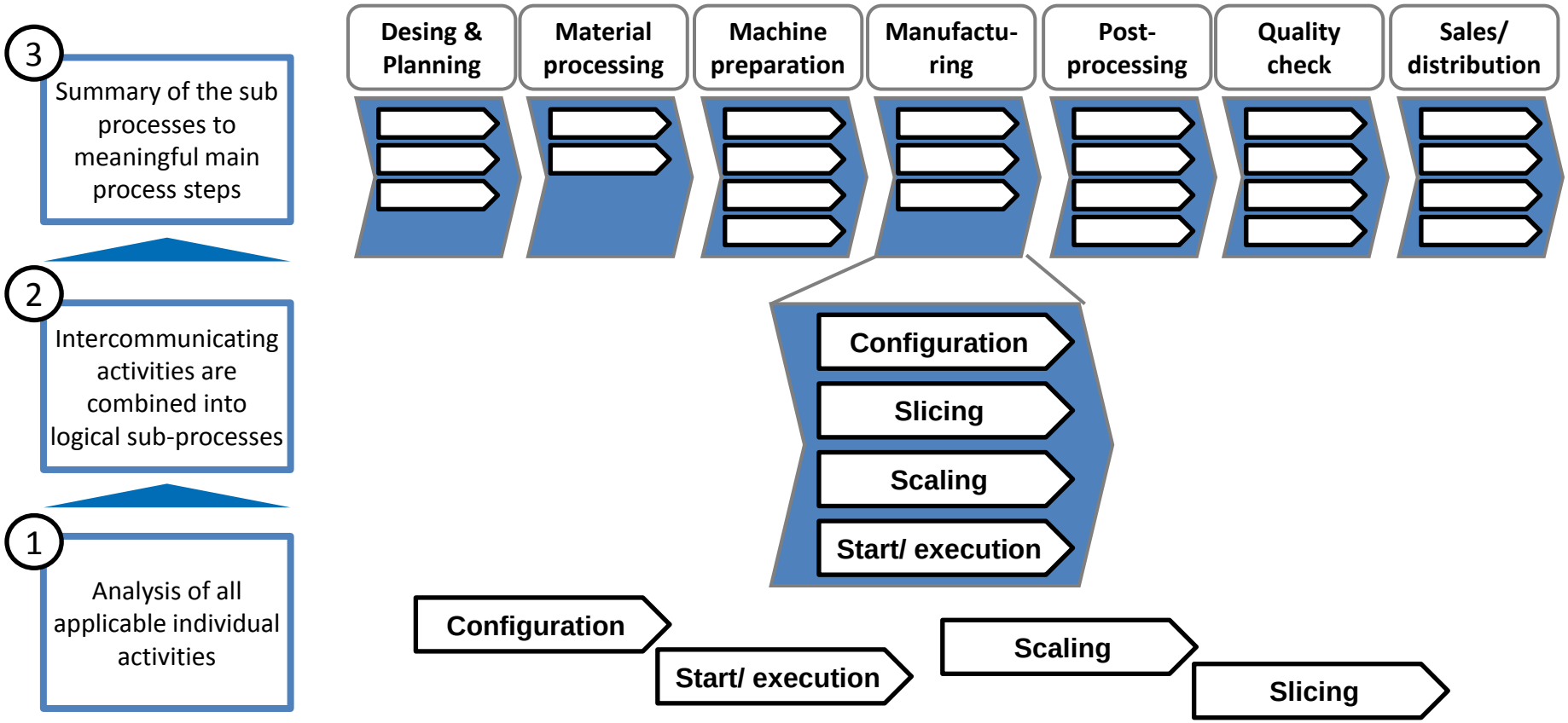
- No fundus of experiences for new technologies/ different products
- A lot of defects and nonconformities
- Process models are not precise enough to make serious process forecasts
- …

Approach


Expert interviews, literature review
Requirement definition
Planning phase (rough model)
Development phase (detailed model)
Configuration and validation phase
Sensitivity analysis
cost-benefit analysis of quality related investments
Safeguarding iterations
Realistic presetting

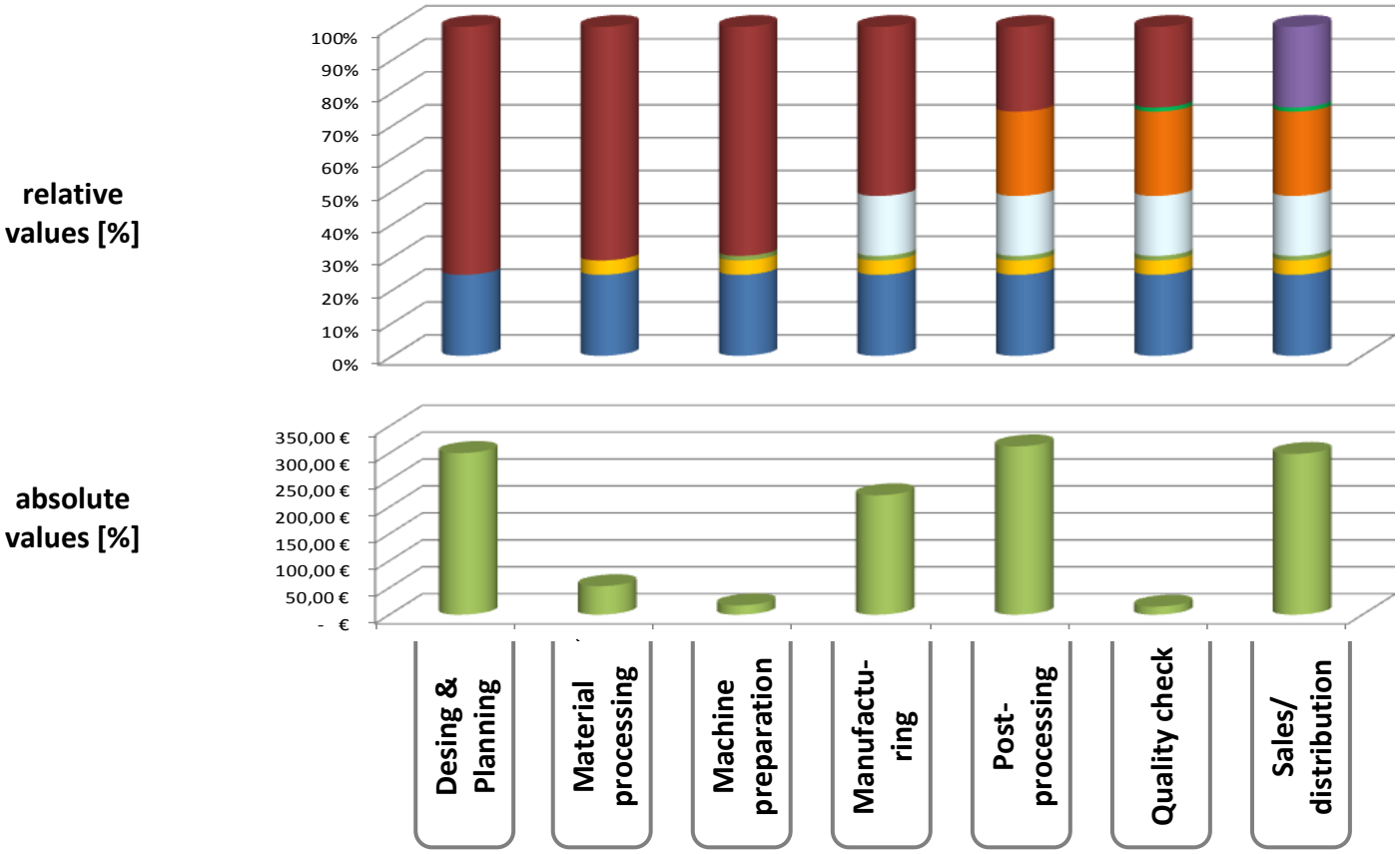
Findings:
The additive manufacturing process

→ 8 Main process steps were identified in the additive manufacturing process



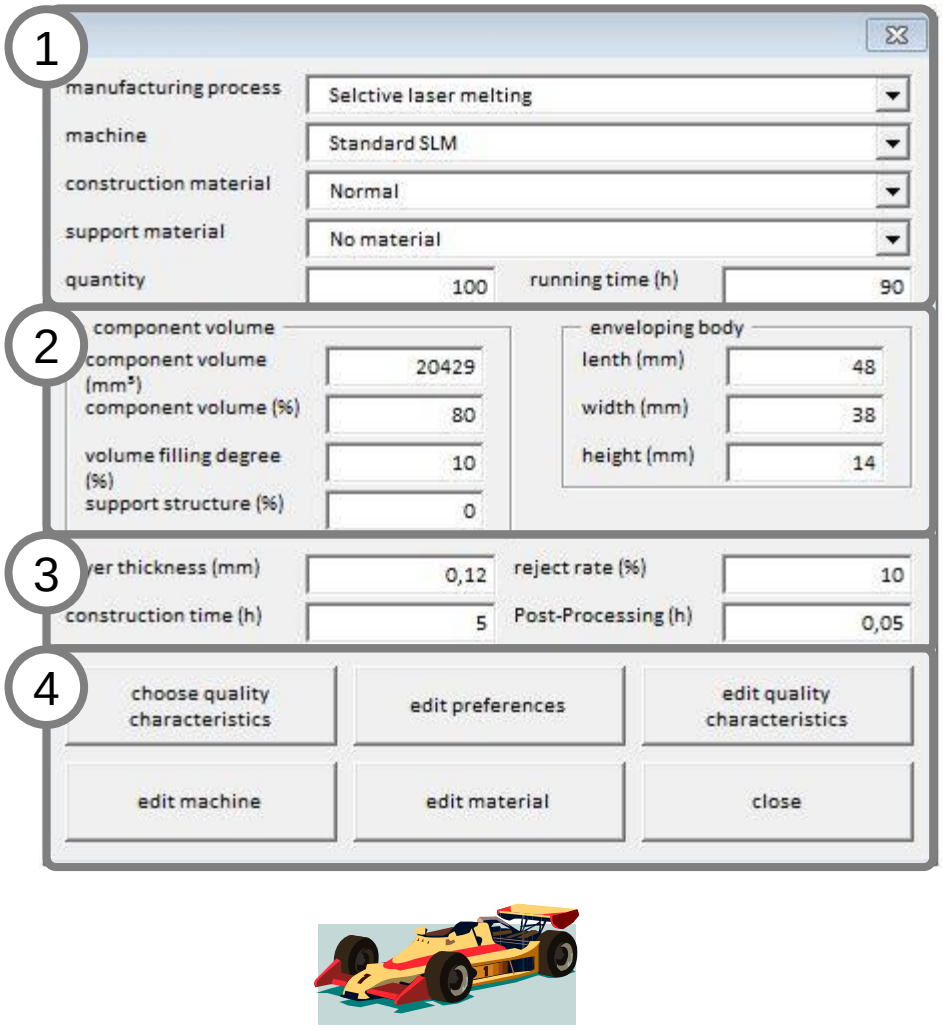
Findings:
Cost calculation of each process step

→ All 8 process steps were calculated based on the companies data

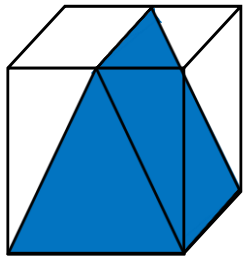


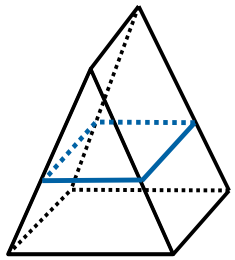
What's happening in the background?

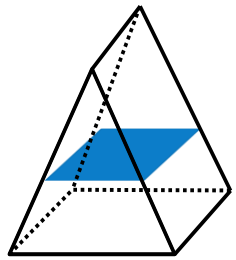
Data Input: Order information



- General job-information have to be given
- Different sub masks can be edited:
  - The machine has to be selected
  - Material has to be selected
  - Quality related parameter have to be set
  - Process Information are deposited

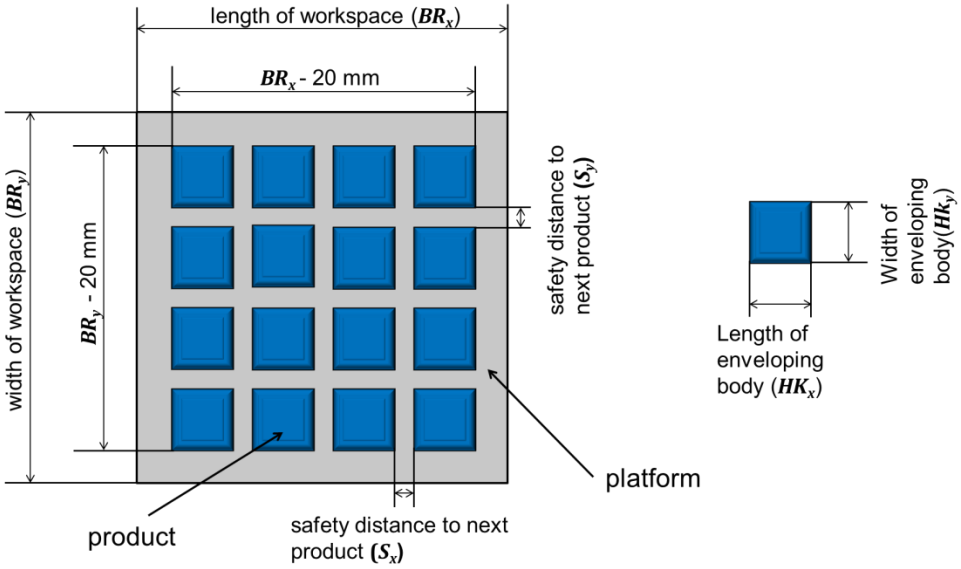






Example:
Calculation of the manufacturing time

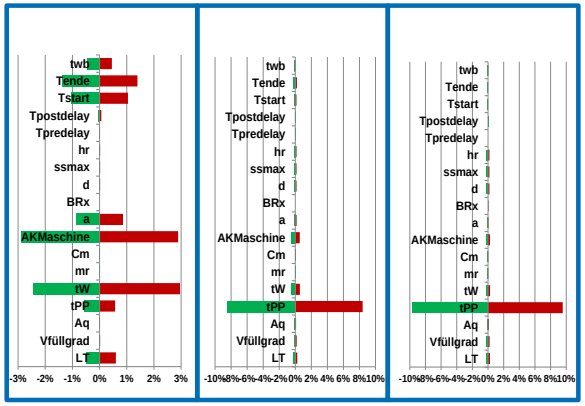
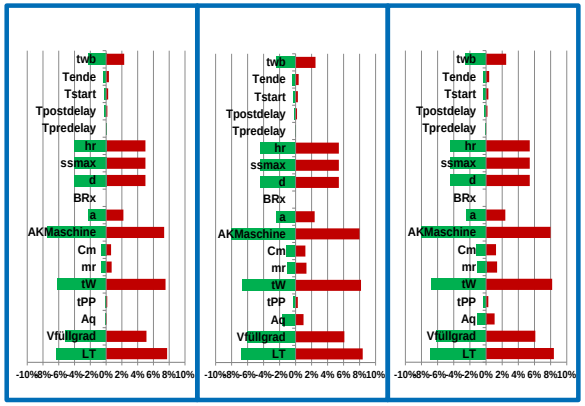
$$t_{Maschine} = \left((Z_S + Z_W) * MAX\left\{ \frac{N_{Aq}}{N_{max}} ; 1 \right\} \right) + N_{Drucke} * Z_V$$



$$N_{max2D} = Rd\left(\frac{BR_x - 20}{HK_x + S_x}\right) * Rd\left(\frac{BR_y - 20}{HK_y + S_y}\right)$$

$$N_{max3D} = Rd\left(\frac{BR_x - 20}{HK_x + S_x}\right) * Rd\left(\frac{BR_y - 20}{HK_y + S_y}\right) * Rd\left(\frac{BR_z - 20}{HK_z + S_z}\right)$$

Sensitivity analysis

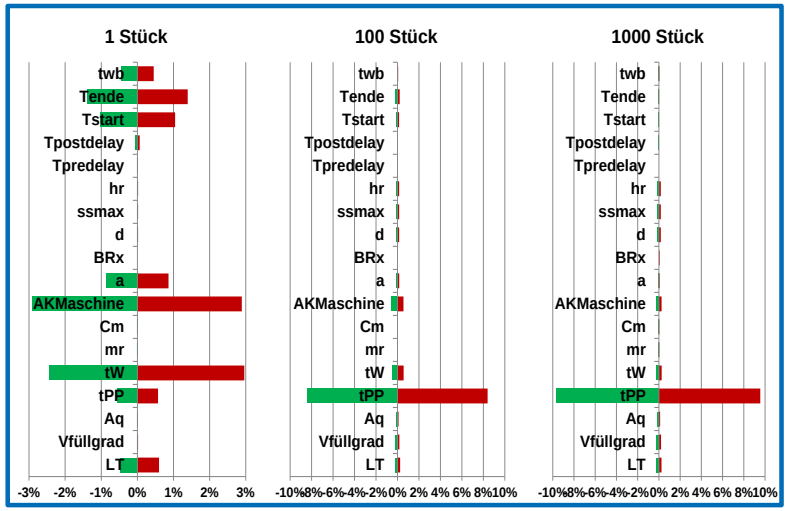
quantity	1	100	1000
Small part **Sensitivity of unit costs during variation of input variables about +/- 10%**			
Big part **Sensitivity of unit costs during variation of input variables about +/- 10%**			

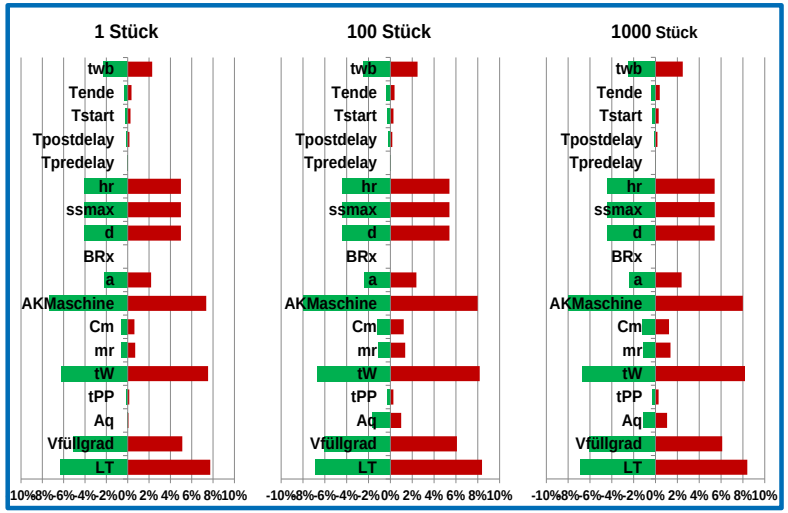
actual example:

45 mm (1:110)

276 mm (1:18)

Findings: Sensitivity analysis





Small parts

Ranking	kleine Stückzahlen	große Stückzahlen
1.	$AK_{Maschine}$ (-2,90%)	t_{PP} (-9,62%)
2.	t_W (-2,43%)	$AK_{Maschine}$ (-0,24%)
3.	T_{ende} (-1,39)	t_W (-0,21%)
4.	T_{start} (-1,04%)	$V_{füllgrad}$ (-0,21%)
5.	a (-0,87)	LT (-0,19%)

Big parts

Ranking	kleine Stückzahlen	große Stückzahlen
1.	$AK_{Maschine}$ (-7,39%)	$AK_{Maschine}$ (-8,03%)
2.	LT (-6,33%)	LT (-6,88%)
3.	t_W (-6,20%)	t_W (-6,74%)
4.	$V_{füllgrad}$ (-5,12%)	$V_{füllgrad}$ (-6,11%)
5.	ss_{max} (-4,08%)	ss_{max} (-4,43)

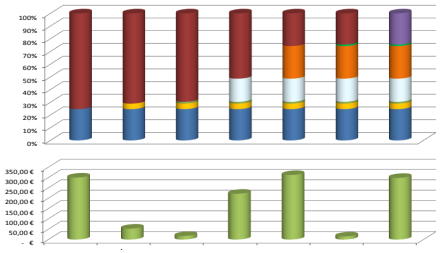
Main cost-influencing factors:

→ investment costs & workload of the machine

→ Post-Processing in case of a high quantity of small parts

→ economies of scale only with small parts

Summary and Outlook



Summary:

- Extension of PSS trough an integration of business process support
- Cost model additive manufacturing technologies
- Development and configuration of the model with companies support and feedback
- Sensitivity analysis

Outlook

- Further development of the software
- Integration of the process model in the product portfolio of the machine provider