

3D Print Congress & Exhibition

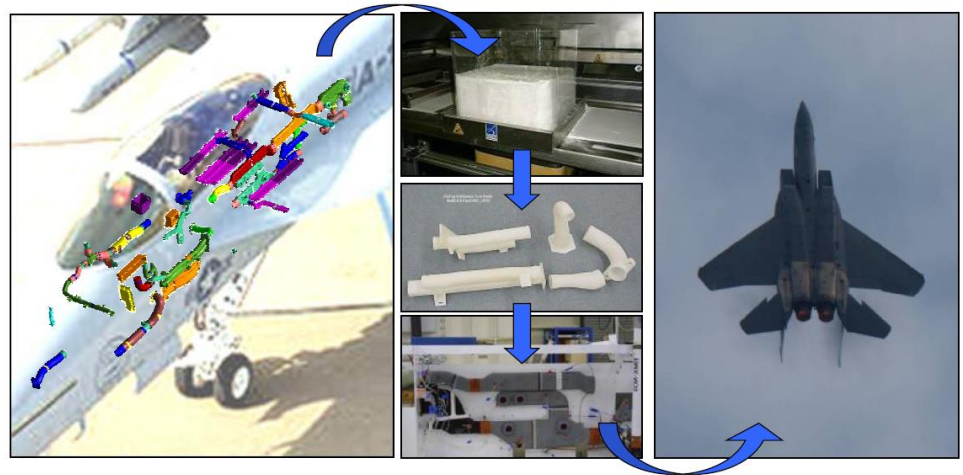
Lyon, 6/2019

Digital Spare Parts

Jouni Partanen, Aalto University



The Boeing company has been utilizing SLS for flight hardware in regular production since 2002, for both military² and commercial³ programs





Aalto University

Source: Aalto University Annual Report 2014
Pictures: Aalto University Communications, Academy of Finland, Lehtikuva Picture Agency



Jouini Partanen
Jouini.partanen@aalto.fi
+358 50 576 9804

Aalto University – Science and Art together with Technology and Business

1849

Helsinki University of Technology

1871

University of Art & Design Helsinki

1911

Helsinki School of Economics

A”

Aalto University

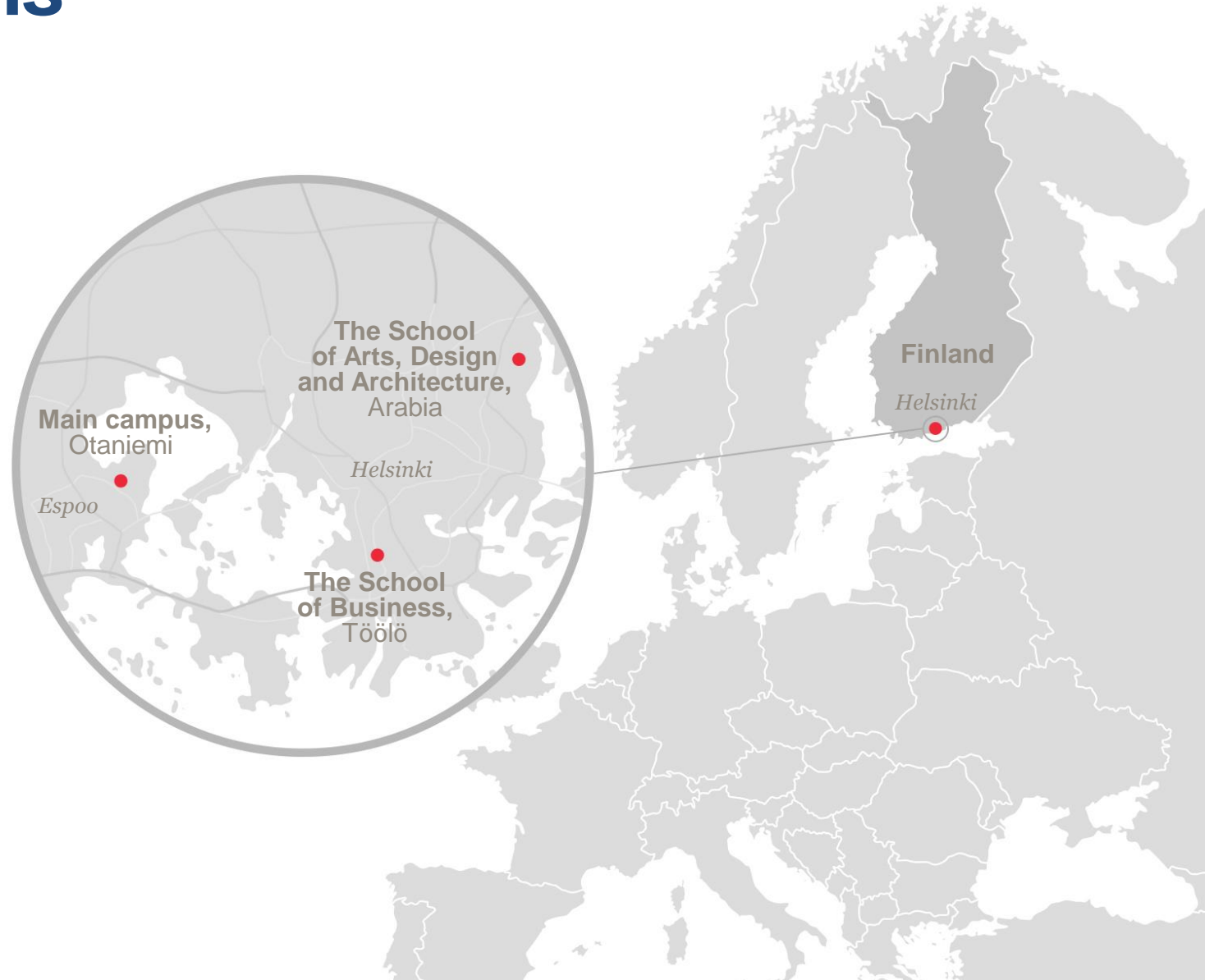
2010

A? Aalto University

A? Aalto University

Prof Jouni Partanen
Jouni.partanen@aalto.fi
+358 50 576 9804

Locations



Aalto University Schools

School of Arts, Design and Architecture

architecture; art; design; media; film, television and scenography

School of Business

accounting; economics; finance; management studies; marketing; information and service management

School of Chemical Engineering

bio products and bio systems; chemistry and materials science; chemical and metallurgical engineering

School of Electrical Engineering

communications and networking; electronics and nanoengineering; electrical engineering and automation; signal processing and acoustics

School of Engineering

built environment; civil engineering; mechanical engineering

School of Science

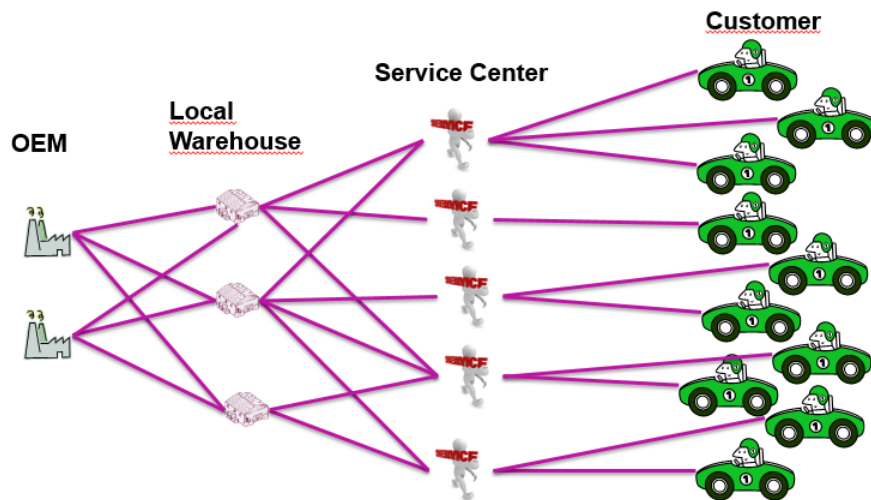
applied physics; computer science; industrial engineering and management; mathematics and systems analysis; neuroscience and biomedical engineering

What are Digital Spare Parts?

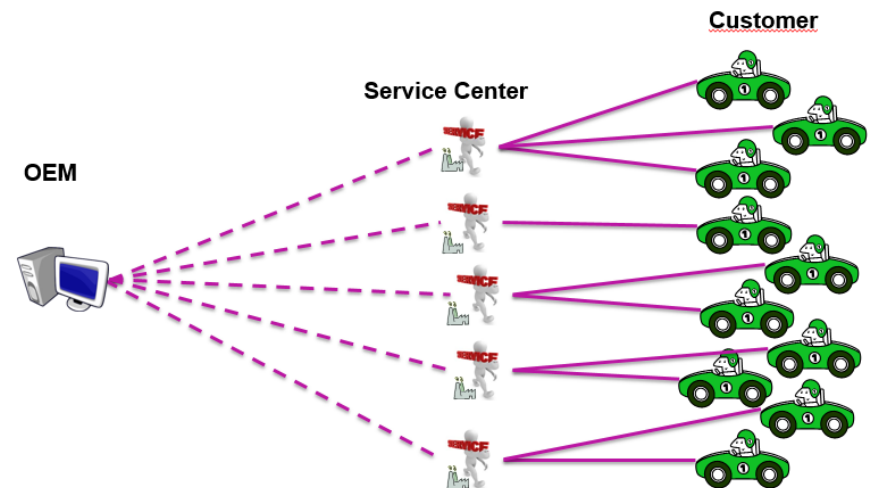
- 3D model and production information are stored Digitally
- “Digital Ware House”
- Manufacturing only when needed – for example by 3D Printing
- Manufacturing close to customer

Digital Spare Parts Logistics

Conventional Parts Logistics



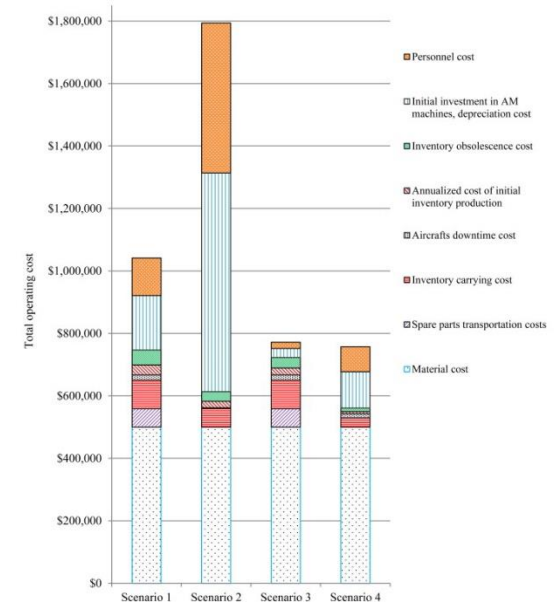
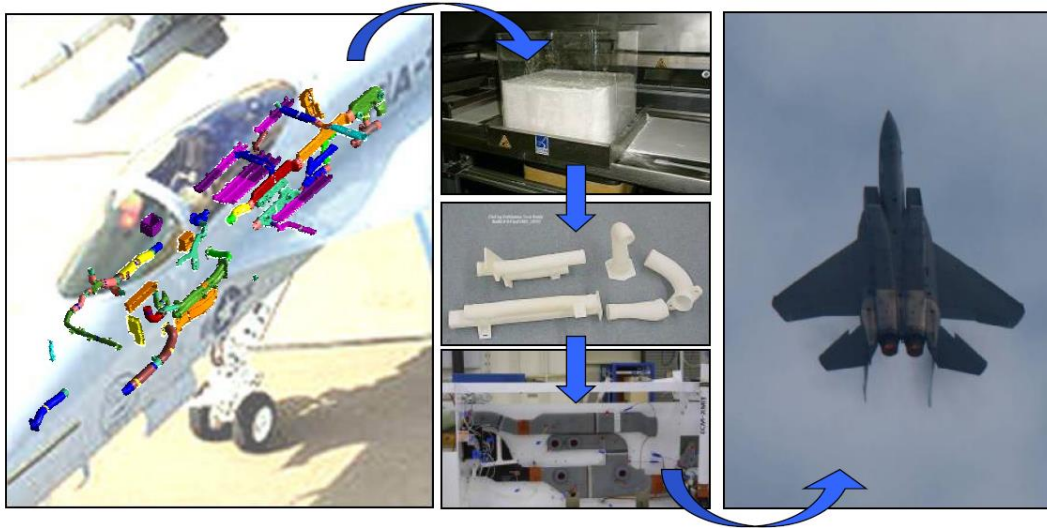
Digital Spare Parts



Jan Holmström, Jouni Partanen, Jukka Tuomi, Manfred Walter, "Rapid manufacturing in the spare parts supply chain," *Journal of Manufacturing Technology Management*, vol. 21, pp. 687 – 697 (2010).

Digital Spare Parts Logistics Modelling

The Boeing company has been utilizing SLS for flight hardware in regular production since 2002, for both military² and commercial³ programs



Siavash Khajavi, Jouni Partanen, Jan Holmström, “Additive Manufacturing in the Spare Parts Supply Chain”, Computers in Industry, vol. 65, pp. 50-63 (2014).

Digital Spare Parts Project (DIVA) 2016 =>



Why Digital Spare Parts?

- Reduced Inventory and Cost
- Faster Service and Less Down Time

Potential:

- Smart Digital Spare Parts
 - Product Identification – Digital Twin
 - Wear Monitoring
- Product Upgrades

Animaatio

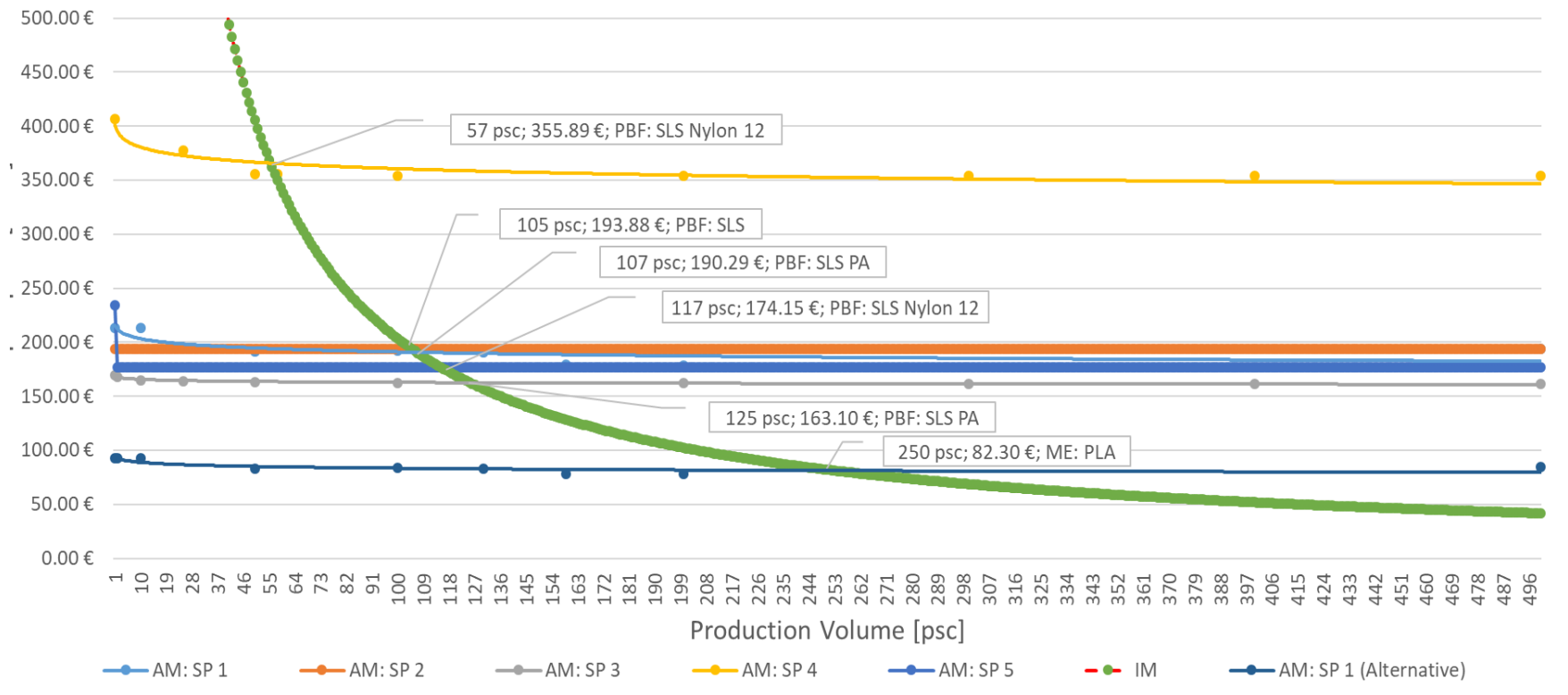
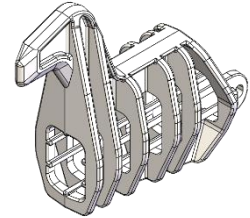
Digital Spare Parts - Issues

- Manufacturing Cost
- Quality
 - Warranty, Liability
 - Intellectual Property Protection
- Availability of 3D model and manuf. data
 - Reverse engineering
 - 3D scanning
 - 3D modelling
- Business Models

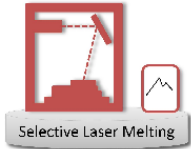
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Break Even for 3D Printing vs. Conventional Production



Cost Analysis for 3D Printed Parts



Machine selection

EOSINT M280 (400W)

Maraging Steel 1.2709

skin-core (Ra 10 - Ra 25)

ADDITIVE MANUFACTURING

COST CALCULATION TOOL

Logistics & Storage

logistics cost (€/part): 50

parts per transport [-]: 40

storage costs per part per year [€]: 2

accumulated downtime cost for this part [€]: 0

setup cost (e.g. mold) [€]: 2000

part consumption [parts/year]: 200

production cost [€/part]: 3

No

Include logistics and storage

Include downtime conventional procurement

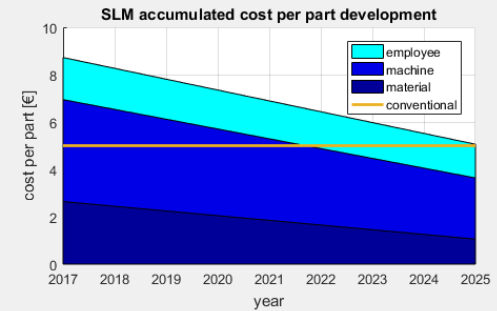
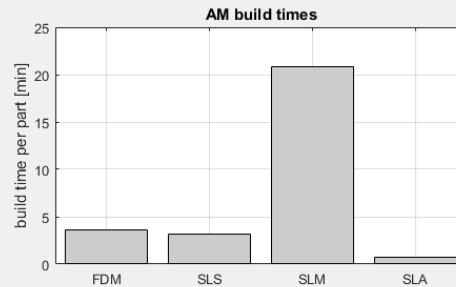
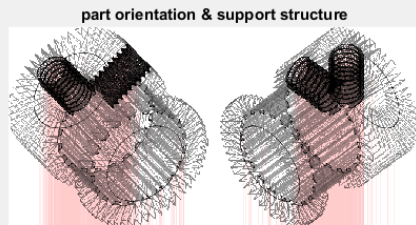
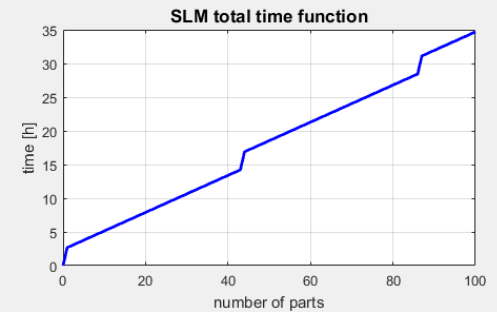
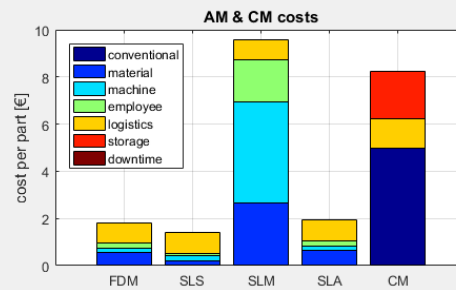
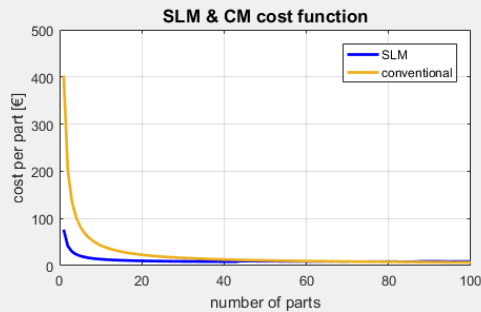
Change setup cost (default value 5000 €)

STL-file not available
 use same STL-file again



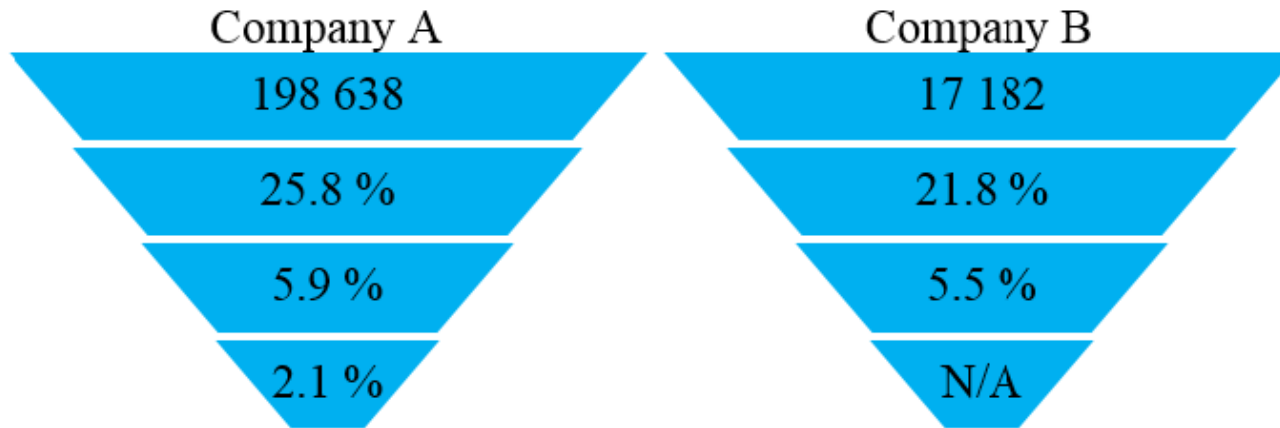
Support: normal | AM batch size: 100 | STL-Input and START | Failure: []

RESET



cost per part [€]	part process time [min]	number per batch [-]	support [%]	AM total logistics cost advantage [€]	AM total storage cost advantage [€]
8.72218	20.8136	43	20.3726	175	400

3D Printing Spare Parts analysis



Phase 1: Number of spare parts in the initial scope

Phase 2: Share of technologically possible spare parts

Phase 3: Share of technologically feasible spare parts

Phase 4: Share of technologically and economically feasible spare parts

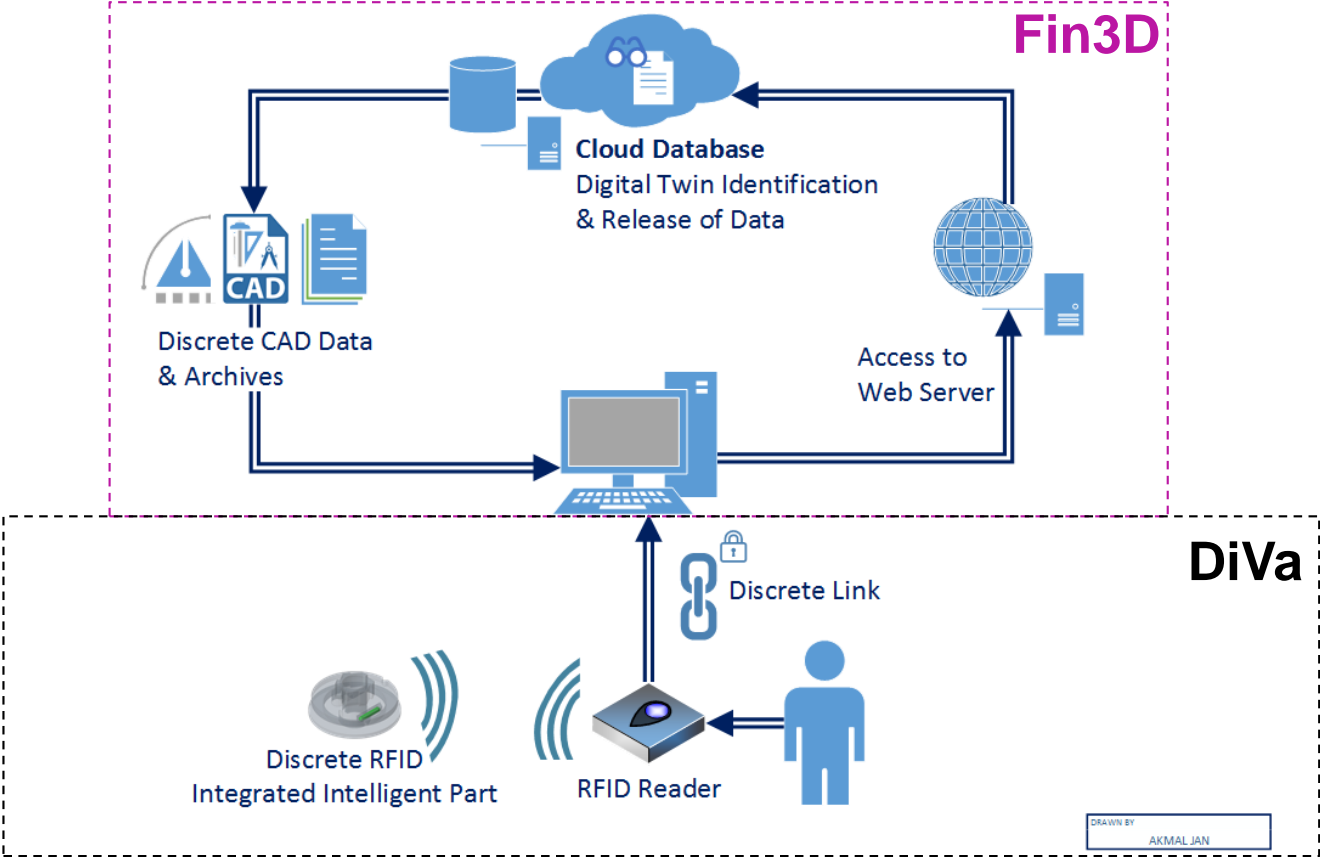
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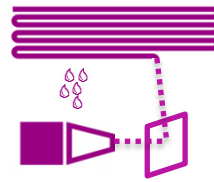
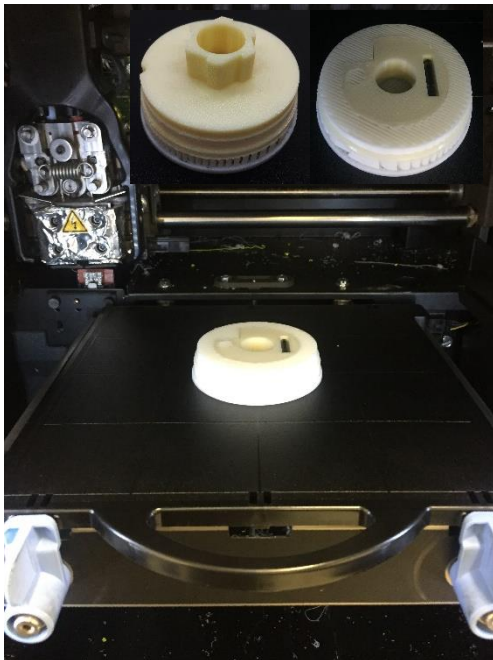
Digital Twin



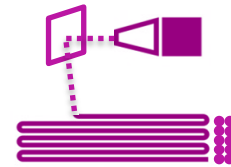
RFID Integration in Digital Spare Parts



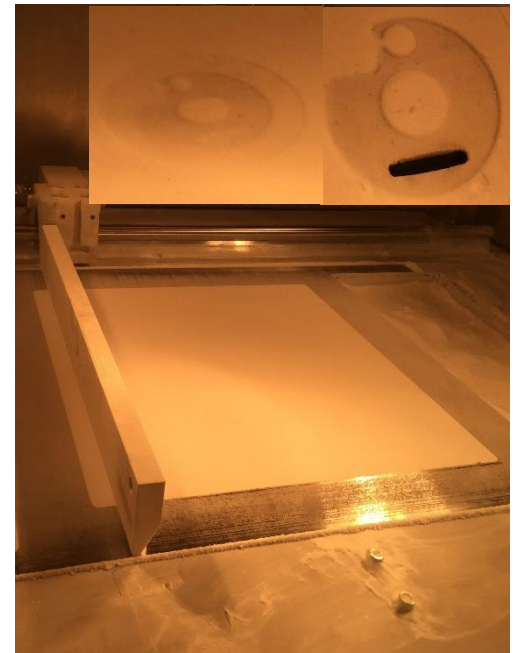
Material Extrusion
ABS +



Stereolithography
Clear V2



Selective Laser Sintering
PP



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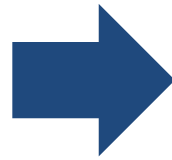
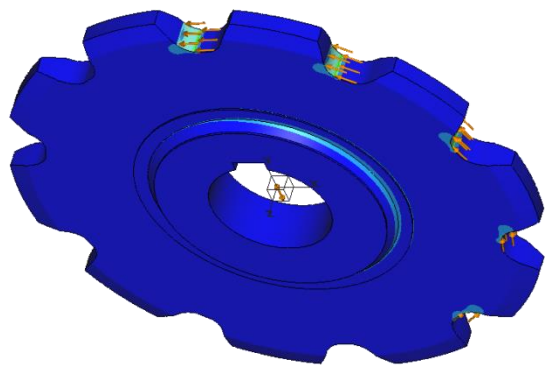
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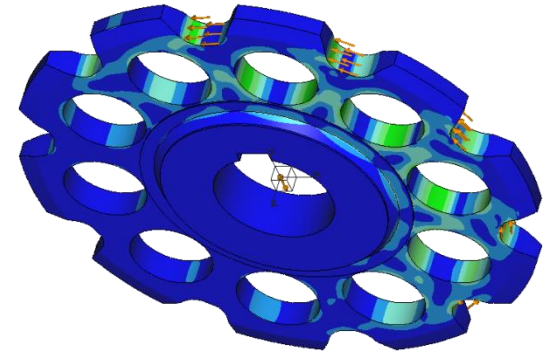
Topology optimization



Reducing Cost trough Mass Reduction



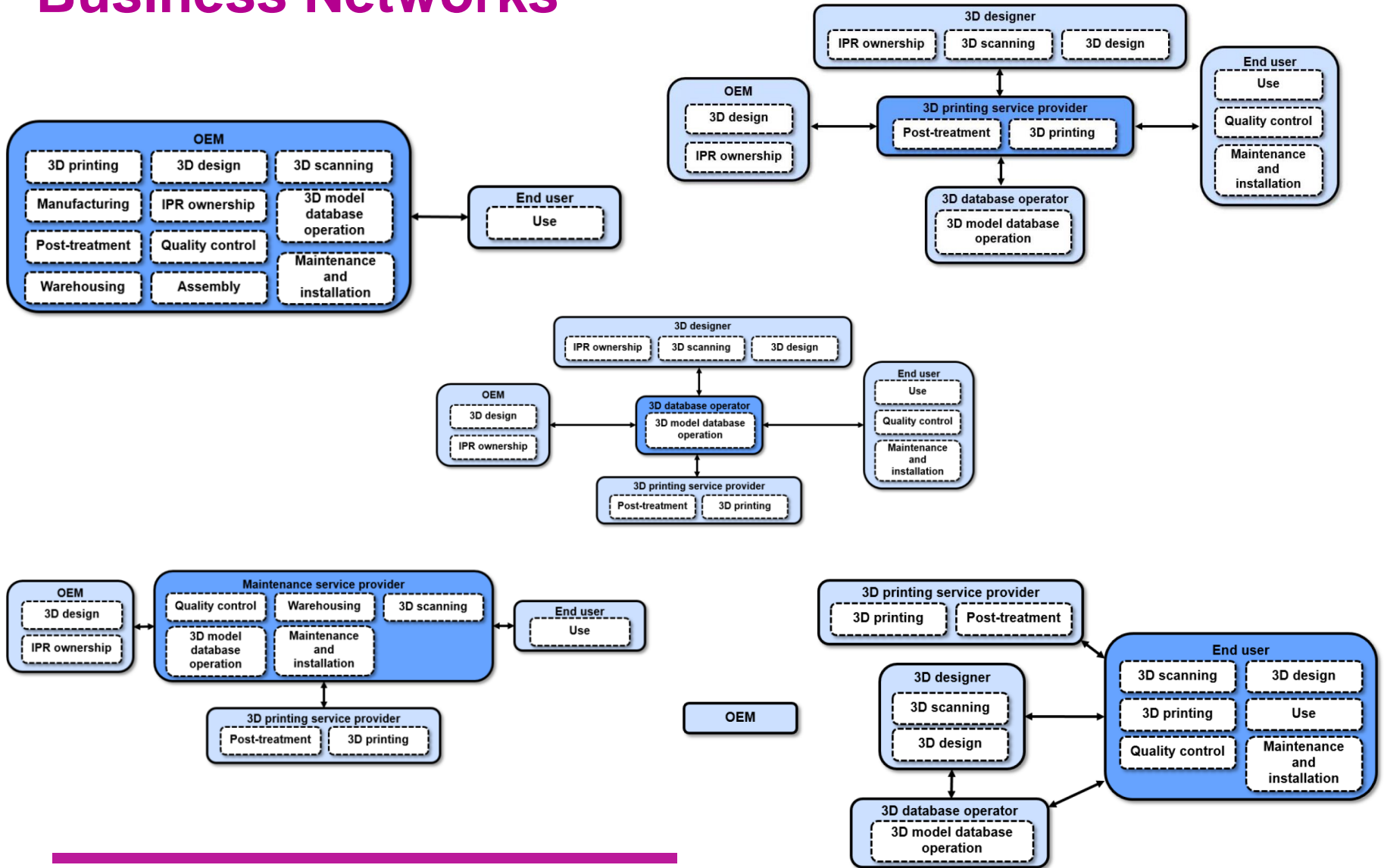
• 35 % less weight



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Business Networks



Acknowledgements

- 3D Manufacturing Group, ME Dept., Aalto Univ.
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- Logistics Group, Aalto Univ.
 - Prof. Jan Holmström

Thank you!

Jouni Partanen

Aalto University

jouni.partanen@aalto.fi

tel. +358 50 576 9804