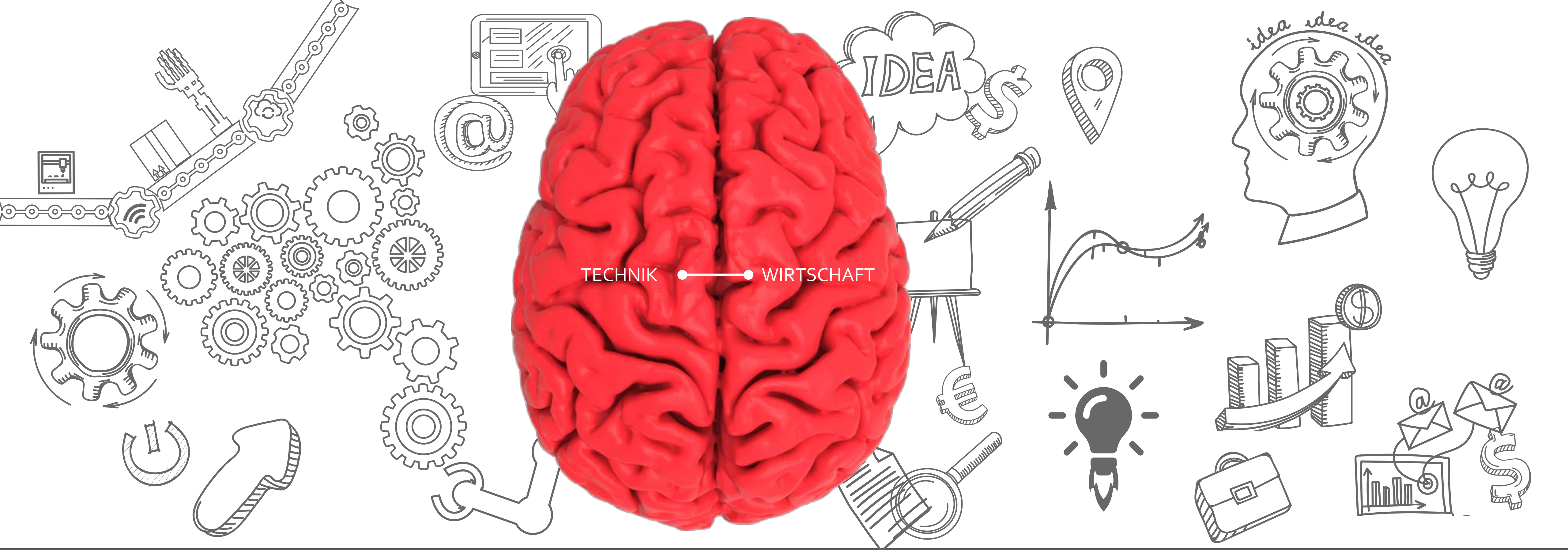

MMO3D-Projekt

Bernhard Heiden, Dornbirn, 13h30-18h00, 20.02.2020

AM-AUSTRIA Vernetzungstreffen,

Ort: 1ZU1 Prototypen GmbH & CoKG, Färbergasse 15, 6850 Dornbirn

16:00-17:00 Kurzpräsentation Version 1.0 (14.2.2020)

„Menschen, die miteinander arbeiten, addieren ihre Potenziale. Menschen, die füreinander arbeiten, multiplizieren ihre Potenziale“

Steffen Kirchner

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FH-Kärnten Wirtschaftsingenieurwesen Studiengang WING & IEM

FH-Prof. Mag. DI Dr. Bernhard Heiden, MBA
Professor for Production Engineering

FH-Prof. DI Dr. Roland Willmann
Professor for Industrial Management

FH-Prof. DI Dr. Erich Hartlieb
Degree programm leader Industrial Engineering
Professor für Innovation- und Technologymanagement

Mag. Dr. Petra Hössl
Senior Researcher
Start Up Initiative

FH-Prof. Dr. Joachim Werner
Professor for Business Adrministration

DI Dr. Josef Tuppinger
Senior Researcher

DI (FH), Mag. (FH) Michael Roth
Scientific Employee

Mag. (FH) Thomas Saier
Scientific Employee

Alexandra Reithofer
Administration

DI Reinhard Tober
Laboratory Engineer Smartlab

Monika Decleva, BSc
Scientific Employee

Tamara Penker
Administration

The CUAS-Interdisciplinary Team for Additive Manufacturing (AM)

KÄRNTEN University of Applied Sciences

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Professor for Physics
Head of Mechanical Engineering & Light Weight Construction Studiengang
Focus: Sensors

FH-Prof. Mag. DI Dr. Bernhard Heiden, MBA

Professor for Production Engineering
Focus: Manufacturing

FH-Prof. DI Dr. Franz Riemelmoser, MBA

Professor for Mechanical Engineering
Focus: Light Weight Materials

AM Team & Related:
- Hannes Oberlercher, BSc MSc (FH)
- FH-Prof. Pascal Nicolay
- FH-Prof. Roland Willmann
- Joseph Zwatz MSc (FH)
- Dominic Zettel MSc. (FH)

Projects
- MMO3D – Development of a Robot Cell for AM, Interreg
- GENFEROS 4.0 – Qualifizierungsnetz FFG – Spreading of AM-technology knowledge for the industry
- Metal 3D-Printing for the Industry
- MMO3D Follow Up

Von der Idee zur erfolgreichen Marktumsetzung

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InnovationsWerkstatt
KÄRNTEN

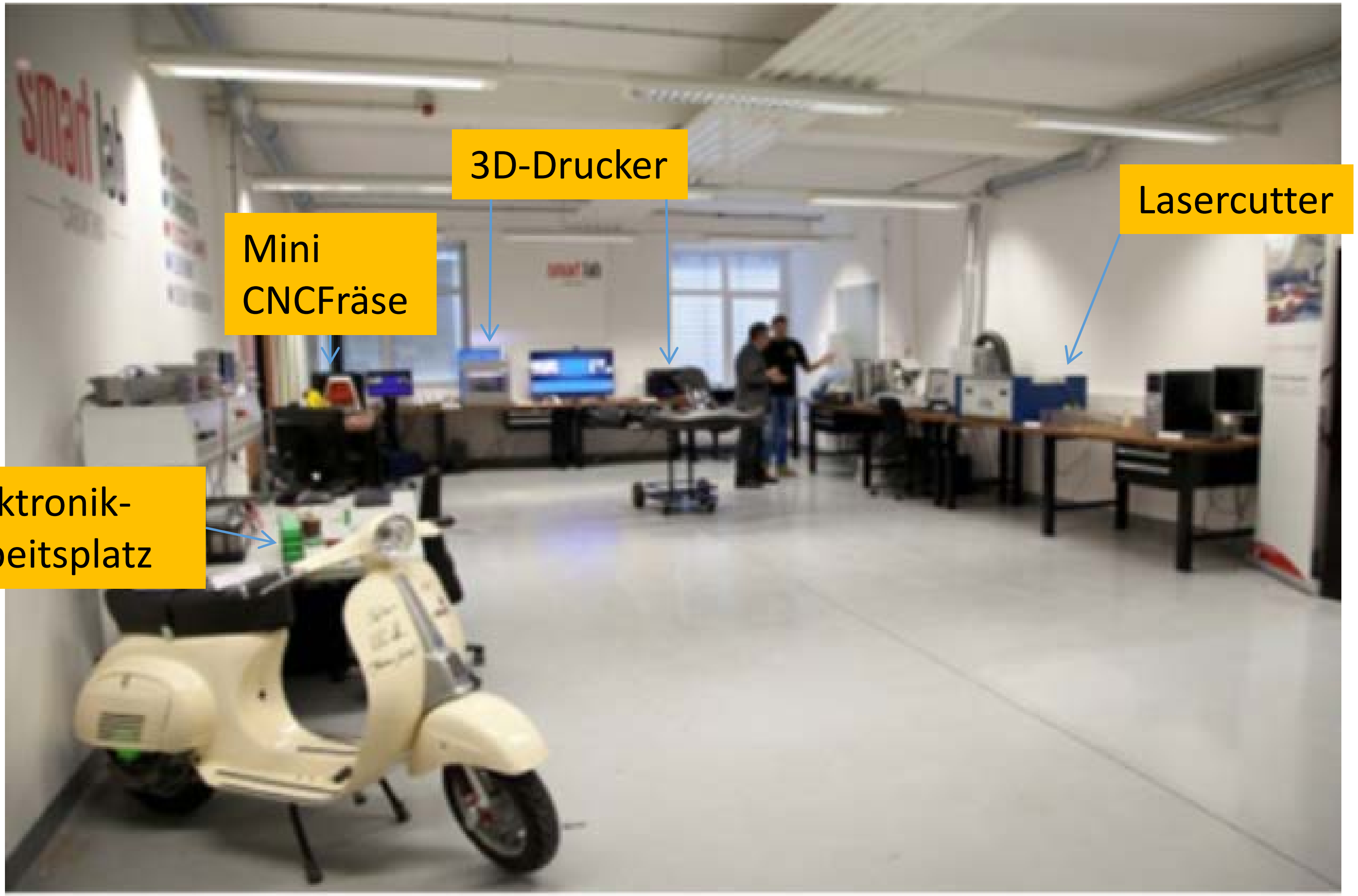
Impuls → Analyse und Zieldefinition → Ideenentwicklung und -verdichtung → Konzept-entwicklung und Geschäftsmodell → Leistungs-entwicklung und Markttest → Umsetzung und Markteinführung

smart lab
CARINTHIA
Prototyping & Industrie 4.0

- CNC
- LASER CUTTER
- SCHNEIDPLOTTER
- 3D-DRUCK / SCANNING
- ELEKTRONIK
- DESIGN / KONSTRUKTION

Konstruktion und Entwicklung → Prototypen-fertigung → Prototypen-validierung

Smartlab (I)


3D-Drucker
Lasercutter
Mini
CNCFräse
Elektronik-
Arbeitsplatz

Smartlab (II)

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University of
Applied Sciences

Aktuelles – Smartlab Lakesidepark

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Inhalt

1 MMO3D Projekt – Motivation und frühere Arbeiten

1 Digitalisation of a line

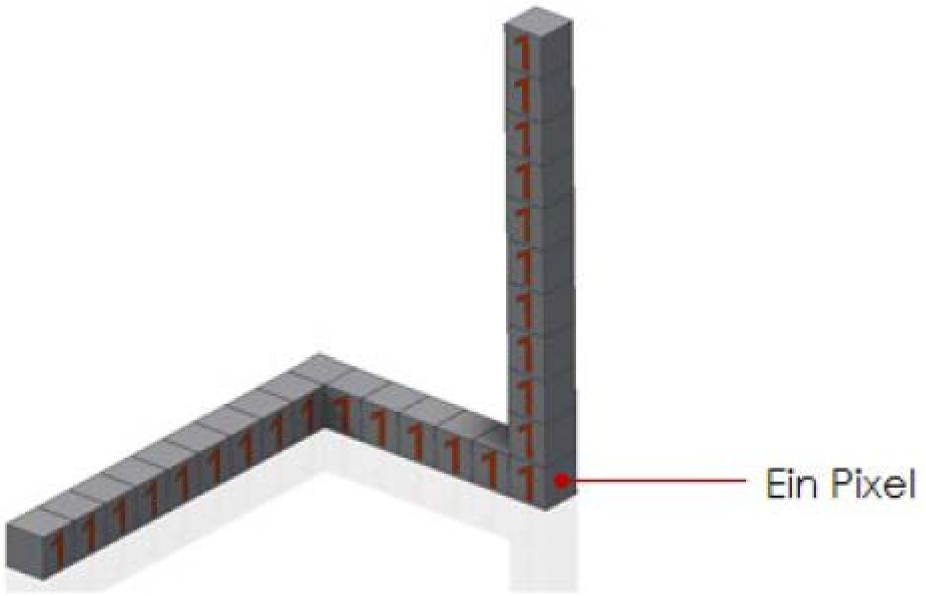


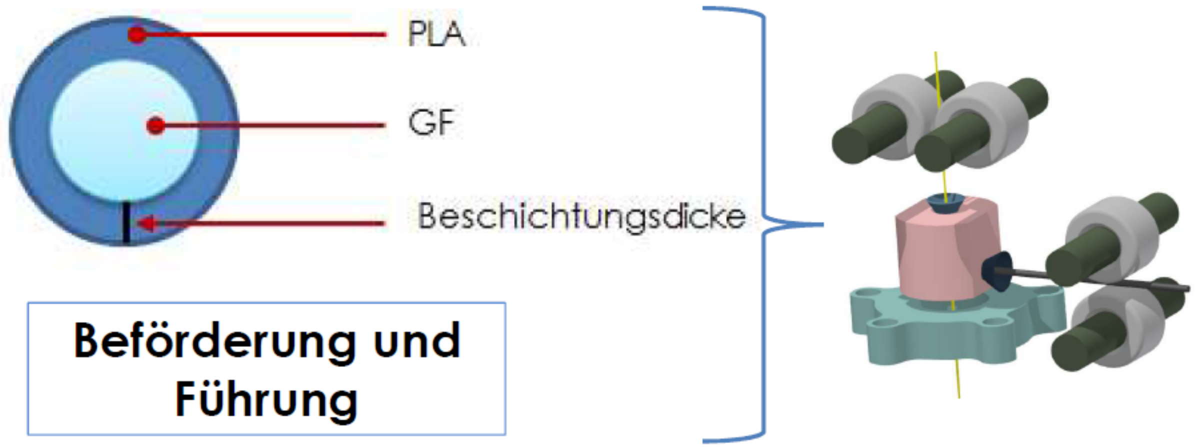
Abbildung 1: Räumliche Materialisierung von Pixelpunkten

[LeU16]

1 Overview of the proposed coating process

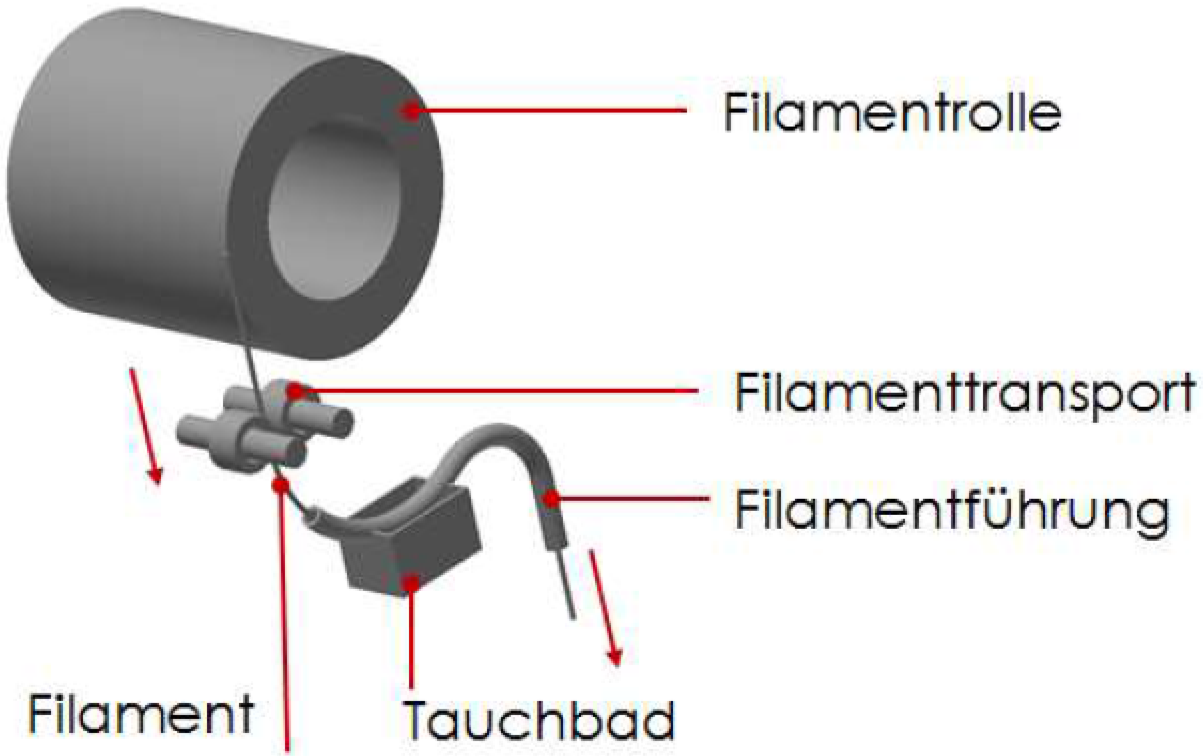
Konzepterstellung für einen Prototypen eines 3D Druckers

- Herstellung des Verbund Werkstoffs (ausgewählte Materialien)
- Beförderung und Führung des Verbundwerkstoffes
- Konzept einer Anordnung von Druckerkomponenten



1 Coating process – first idea (I)

- Beschichtung des GF-Filaments im Tauchbad
- Filamenttransport durch angetriebene Rollen
- Filamentführung nach der Beschichtung berührungslos



[LeU16]

1 Functional analysis with TRIZ

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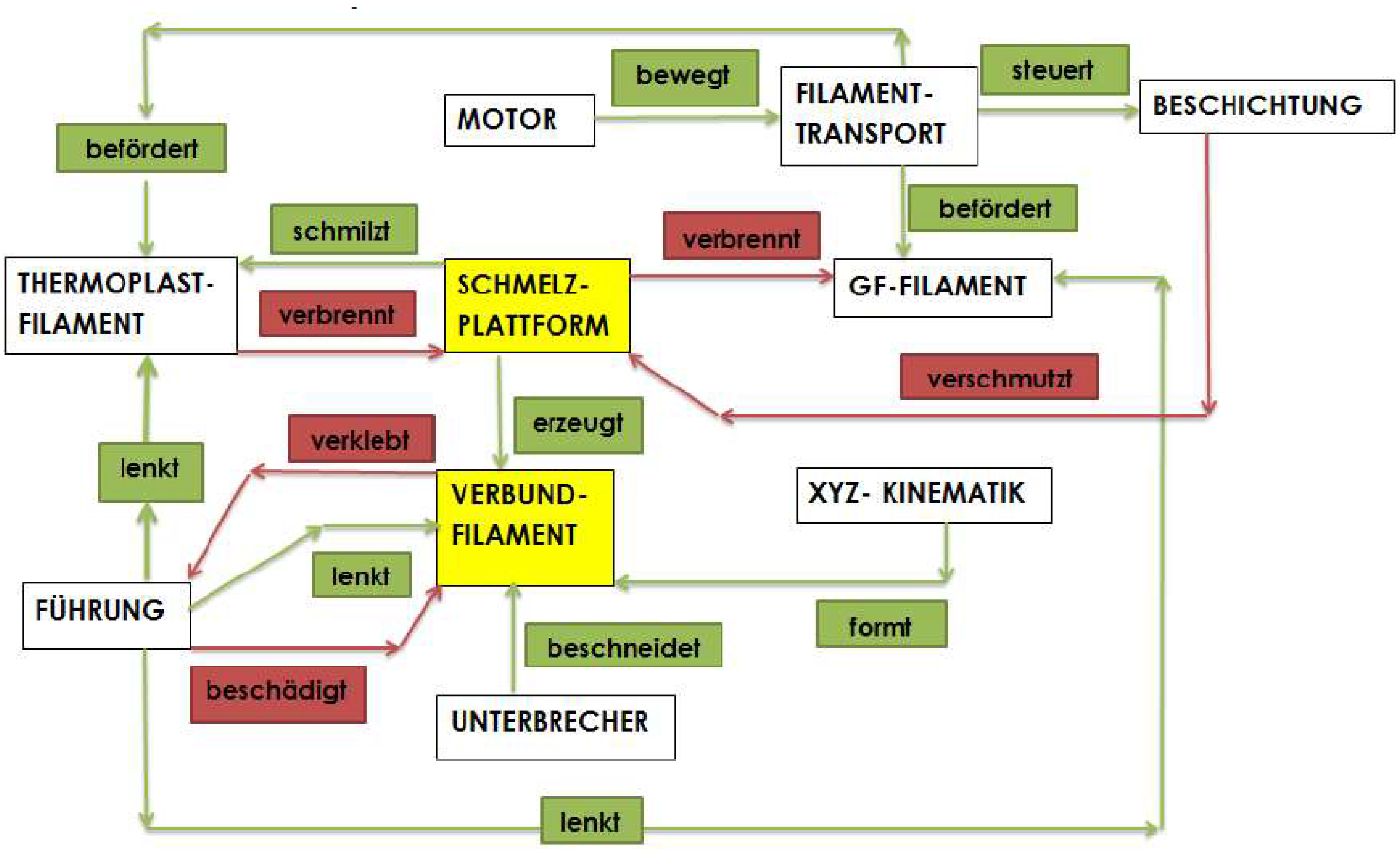

[LeU16]

1 First Printing Head Concept

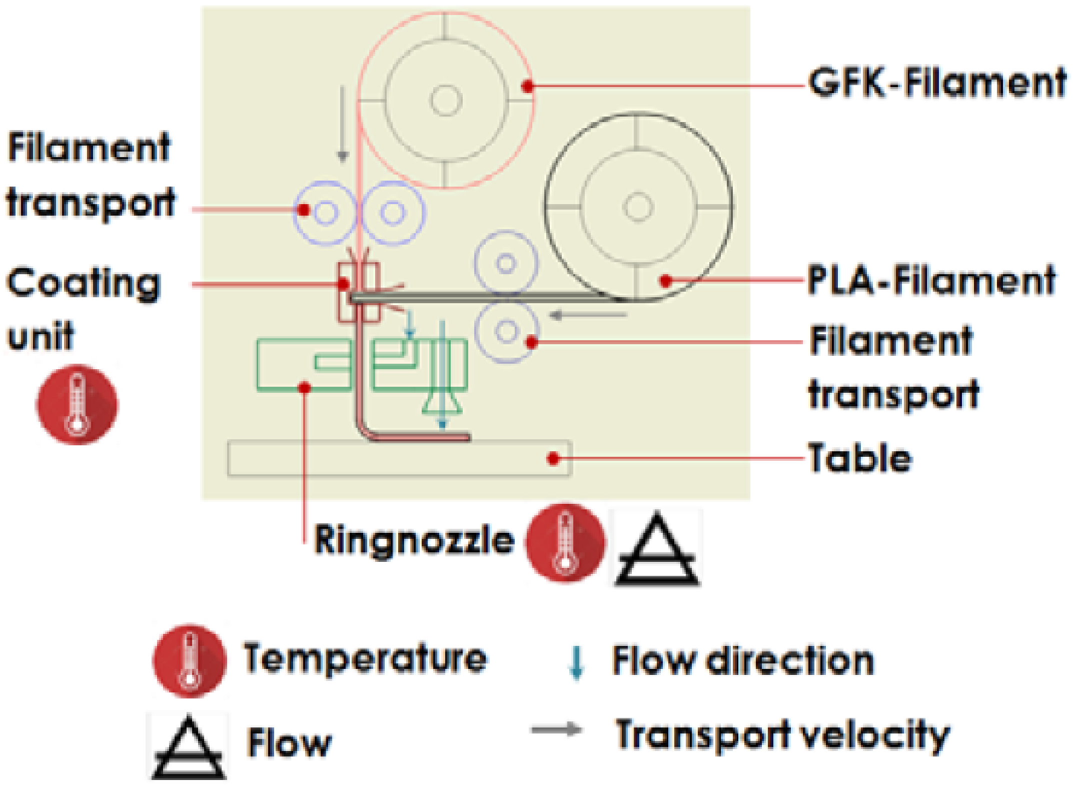

Figure 2: Additive manufacturing concept for coated fibers - vertical layout [1]

[LeU16]

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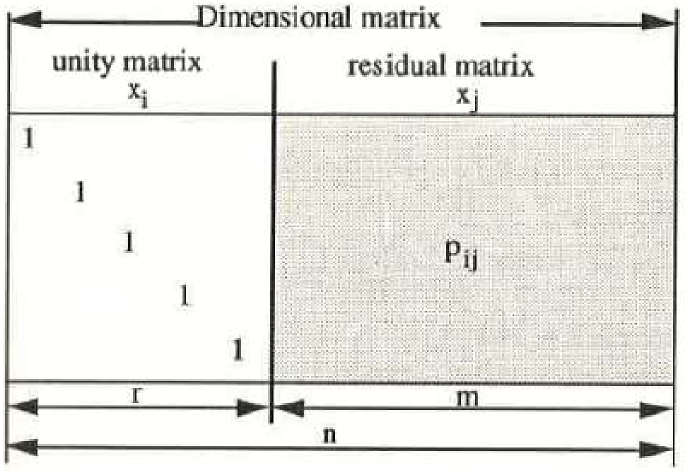
Parameter Temperatur, Viskosität…

(Mögliche)

Dimensions-matrix

(m=n-r)



PI-Zahlen

(Dimensionslos)

$$\pi(1) = \frac{d}{\Delta T^0 * \nu D^{-1} * \nu F^1 * g^0} = \frac{d * \nu D}{\nu F} \left[\frac{m * \frac{m}{s}}{\frac{m^2}{s}}\right]$$

Dimensionslose Kennzahlen (Reynolds…); Einfluss-parameter; Zähigkeit (Viskosität)

[ZIM91]

[1]M. Zlokarnik, Dimensional Analysis and Scale-up in Chemical Engineering, New York, Berlin: Springer Verlag, 1991.

1 Coating Thickness - velocity

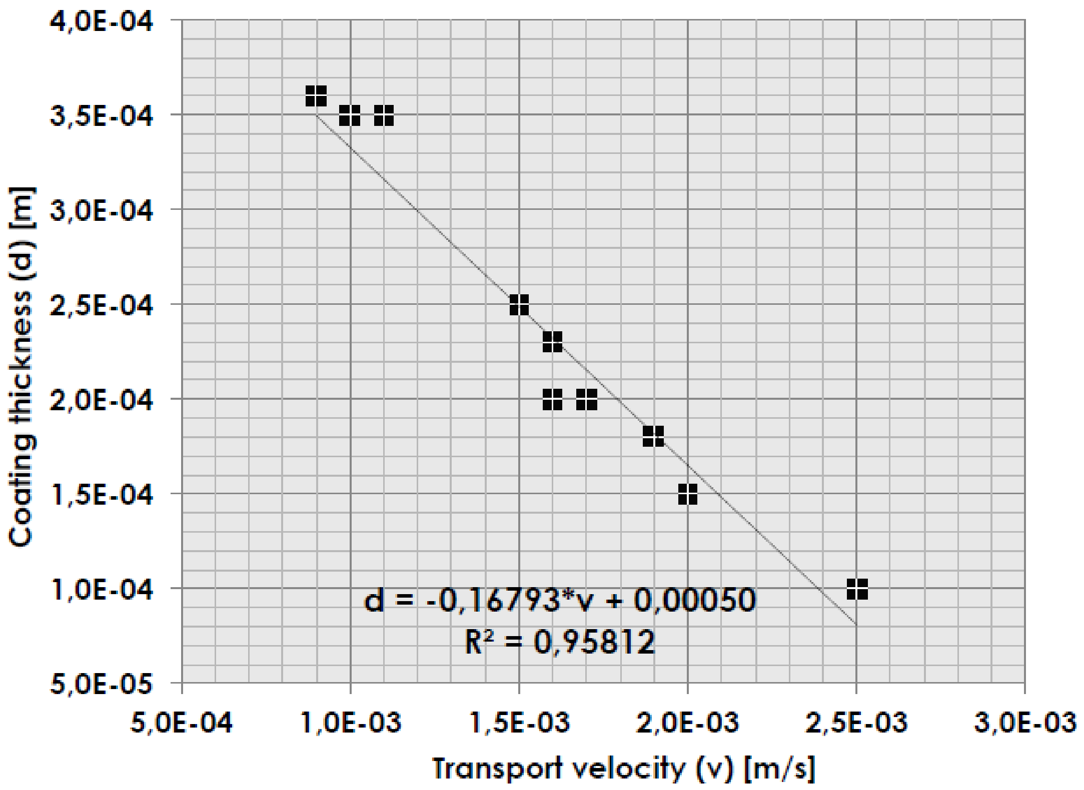


Figure 4: coating thickness d over fiber transport velocity v according to [1]

[LeU16]

2 MMO3D Projekt - Inhaltliches

2 Projektinfo

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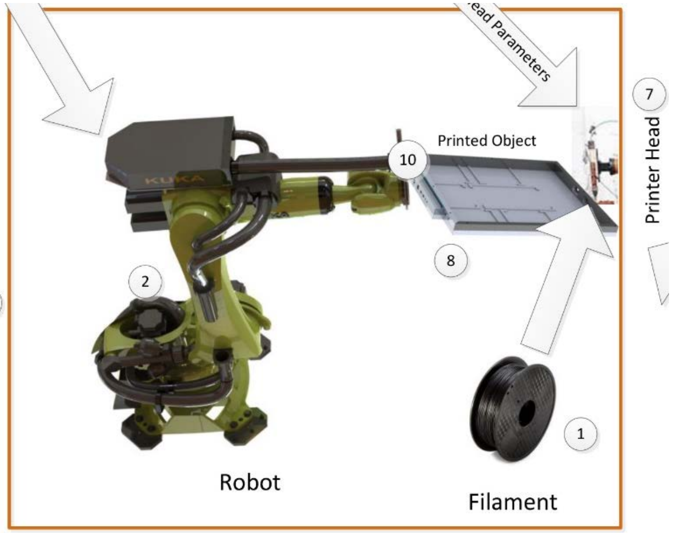
- Entwicklung einer Roboterzelle für das 3D-Drucken von Composite-, Leicht- und Natur-Materialien → ermöglicht die Herstellung auch geometrisch komplexer Produkte im Vergleich zu konventionellen 3D-Printern
- Verwendung und/oder Entwicklung von kontinuierlich faserverstärkten Filamenten (CFF) und Adaptierung des 3D Printkopfes für diese Anwendungen → CFF liefert hochfeste Leichtmaterialen (Carbon und auch Naturfasern sollen im Projekt verwendet werden)
- Demonstration → Batterie-Box für e-cars (Leichtbaumaterialien erforderlich)

ROBOTEH
AVTOMATIZACIJA, ROBOTIZACIJA

Development of robot cell

University of Ljubljana
Faculty of Electrical Engineering

Programming of robot cell and 3d printing head



W3C WOOD

3d printing head & CFF
Expertise for natural fibers

Oprema Ravne

Construct e-car incl. battery box

CARINTHIA UNIVERSITY OF APPLIED SCIENCES
FACHHOCHSCHULE KÄRNTEN

Material testing + 3d printing head

Interreg SLOVENIEN - ÖSTERREICH
REPUBLIKA SLOVENIJA
SLUŽBA VLADE REPUBLIKE SLOVENIJE ZA RAZVOJ IN EVROPSKO KOHEZIJSKO POLITIKO
KWF Kärntner Wirtschaftsförderungs Fonds

2 W3C

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Interreg SLOVENIJA - AVSTRIJA

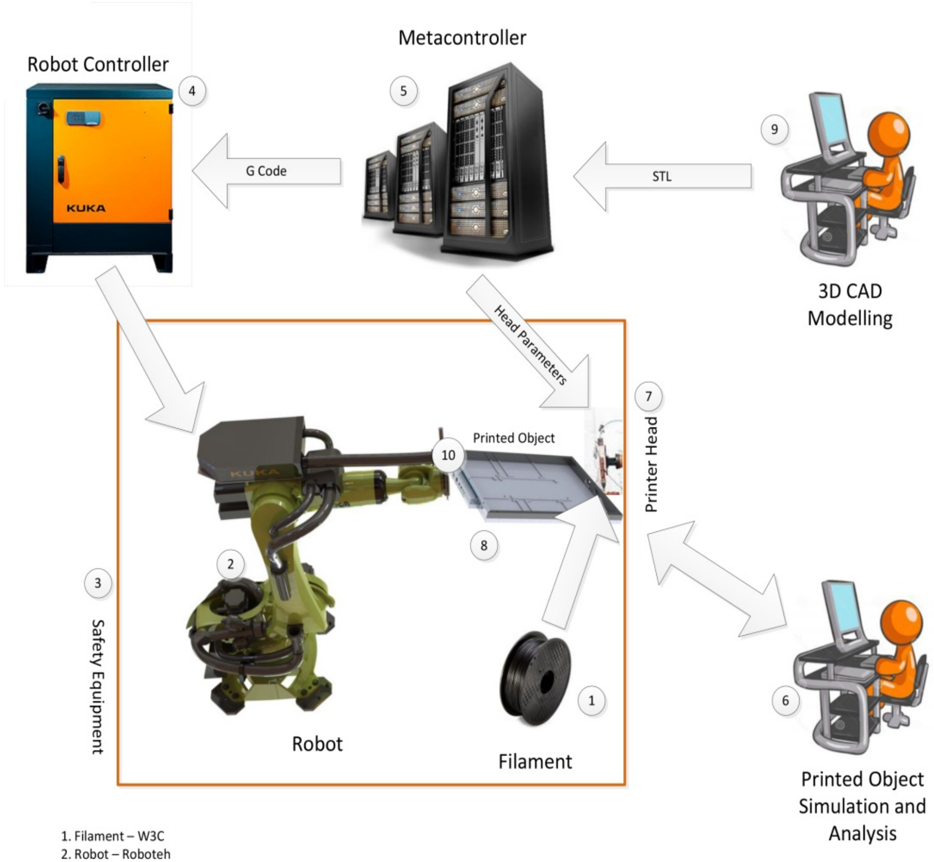
REPUBLIKA SLOVENIJA
SLUŽBA VLADE REPUBLIKE SLOVENIJE ZA RAZVOJ IN EVROPSKO KOHEZIJSKO POLITIKO

KWF Kärntner Wirtschaftsförderungs Fonds

Oprema Ravne

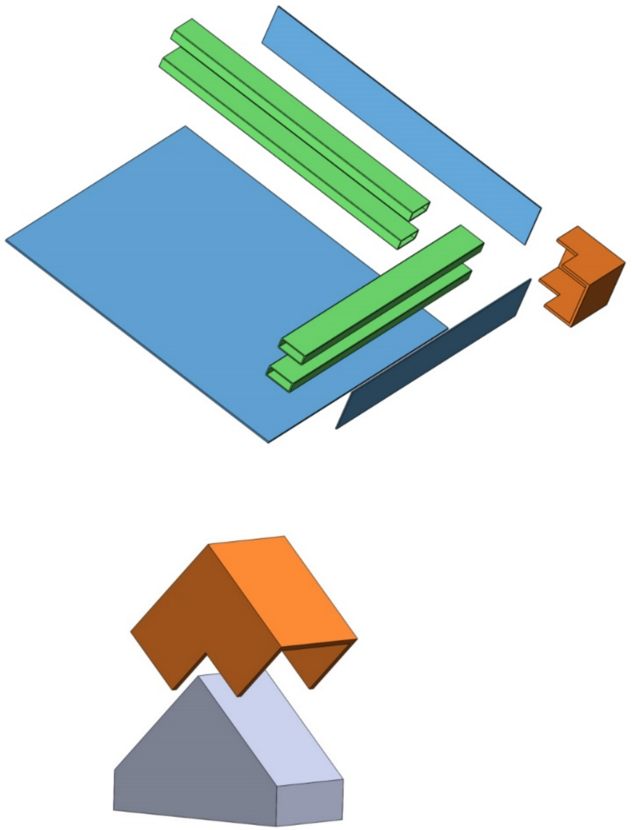
ROBOTEH

2 Concept of the Robot Cell MMO3D



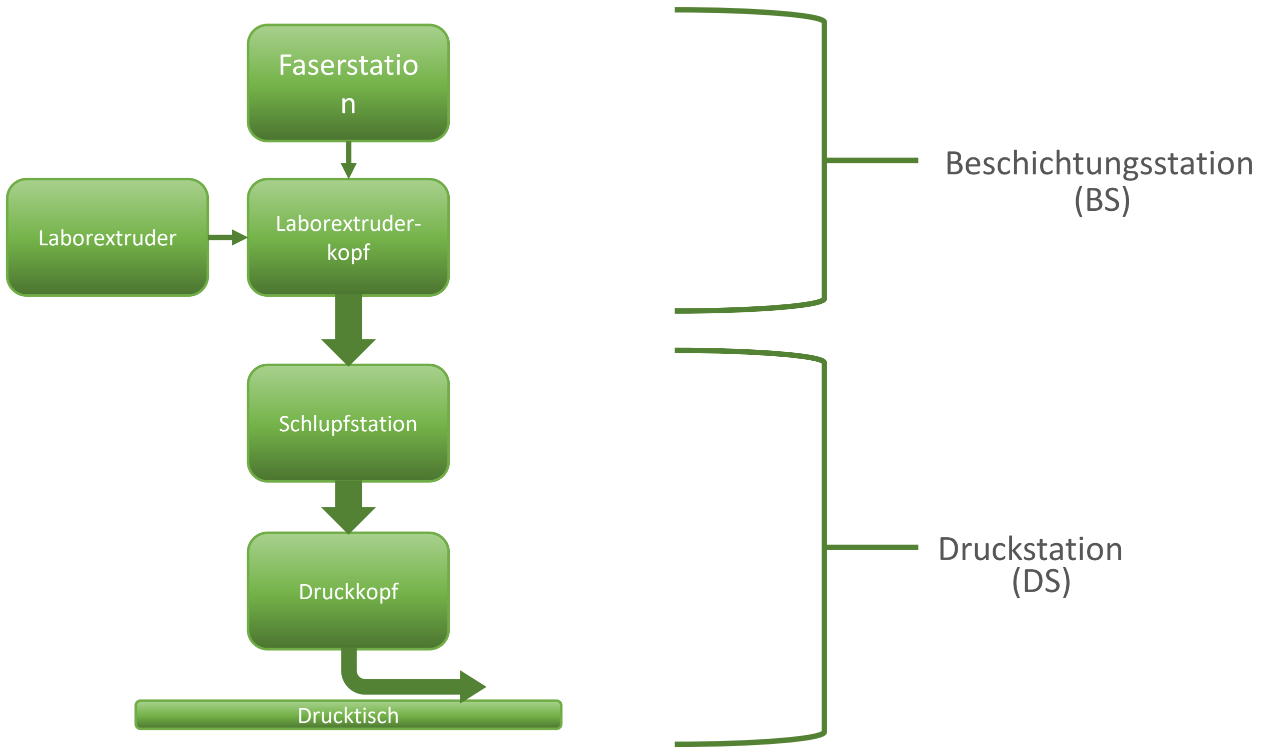
1. Filament – W3C
2. Robot – Roboteh
3. Safety Equipment – Roboteh
4. Robot Controller – Roboteh
5. Metacontroller – FE
6. Printed Object Simulation and Analysis - FH
7. Printer Head – W3C
8. Printed Object – Oprema
9. 3D Cad Modelling – Oprema
10. Grippers and Clamps – Oprema

2 Battery Box as Demonstration Object

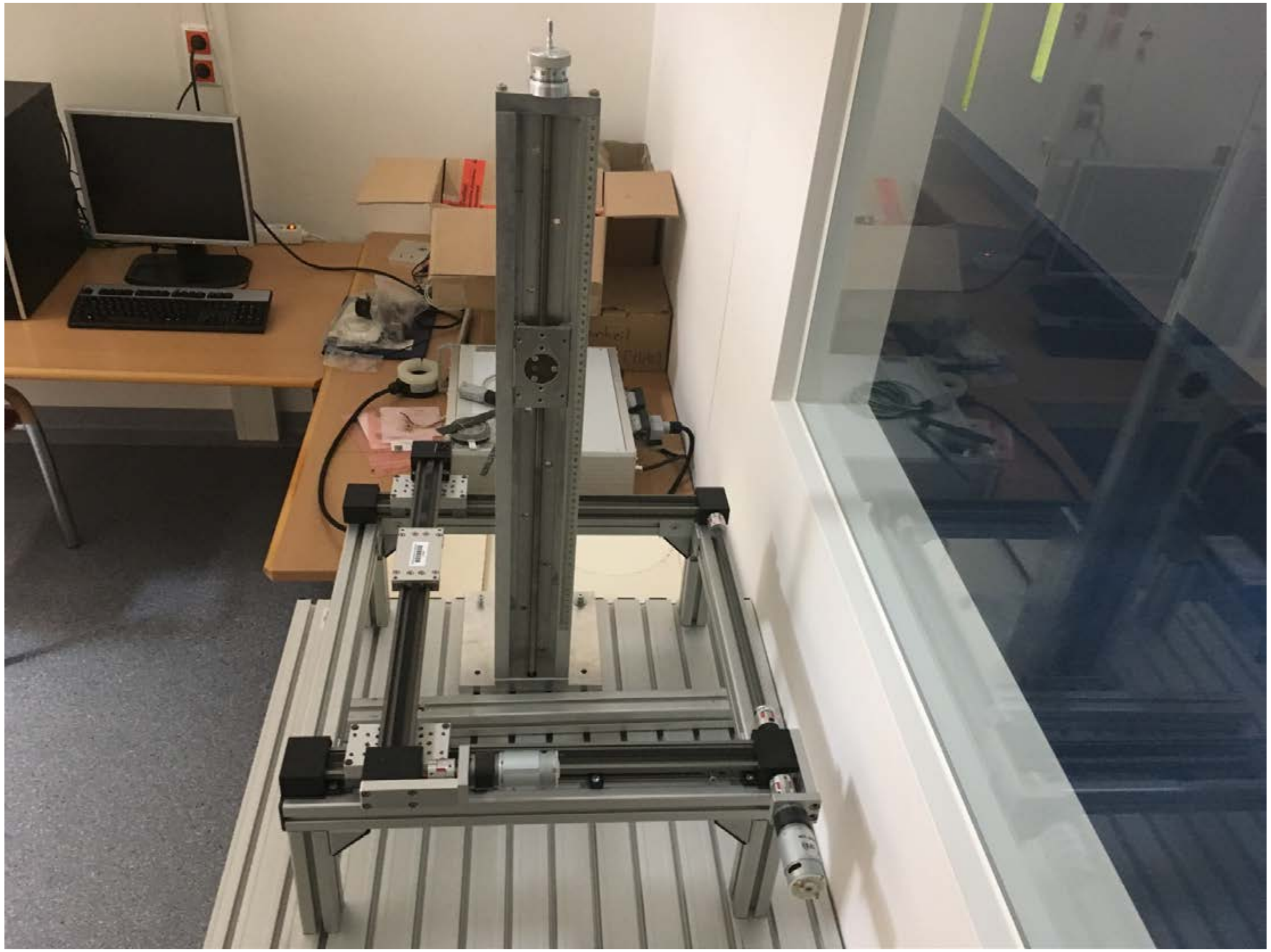


3 Druckkopf

3 Druckkopfentwicklung - Konzept



3 X-Y-Z positioning stage



3 Simulation (3-point bending test)

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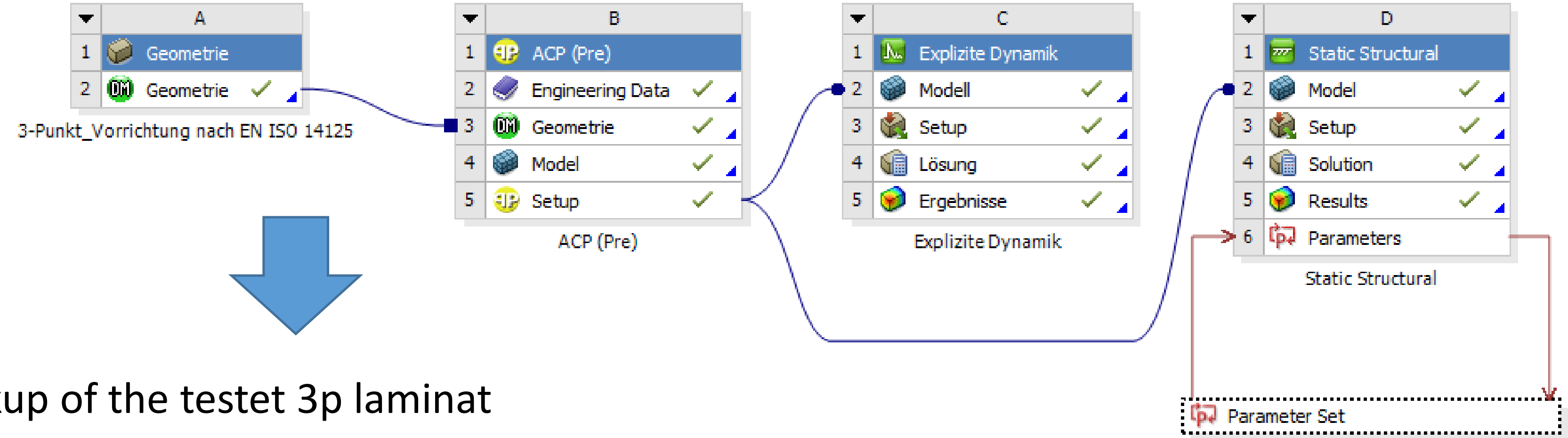
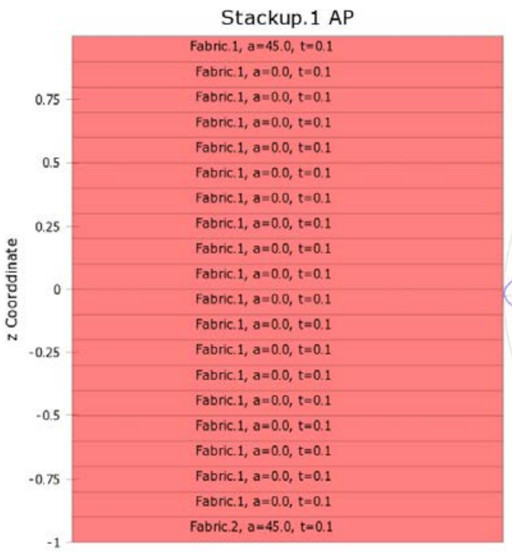
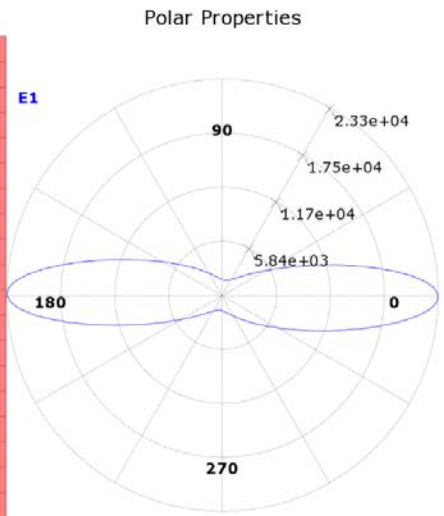
Simulation set-up in Ansys ACP

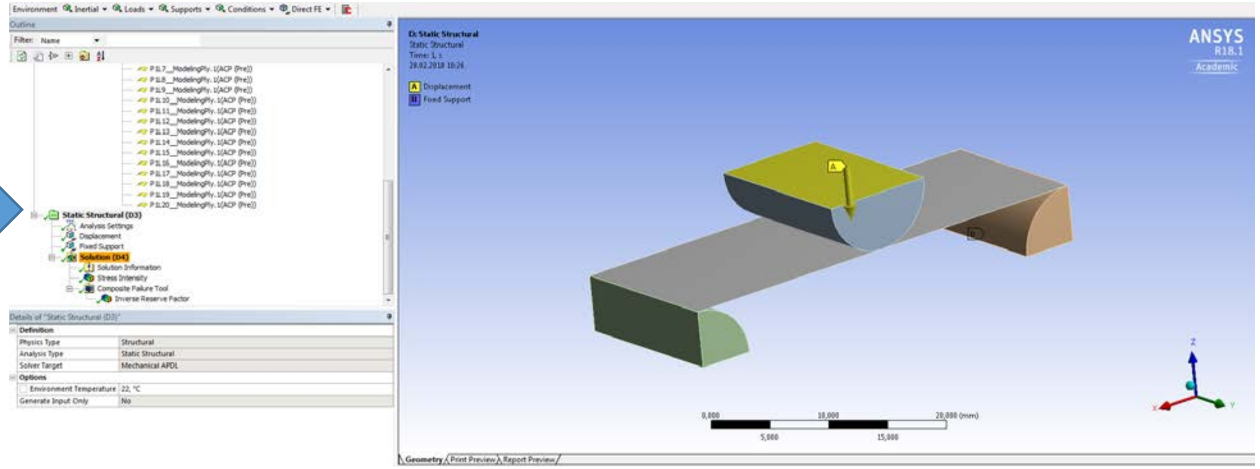


Stackup of the testet 3p laminat

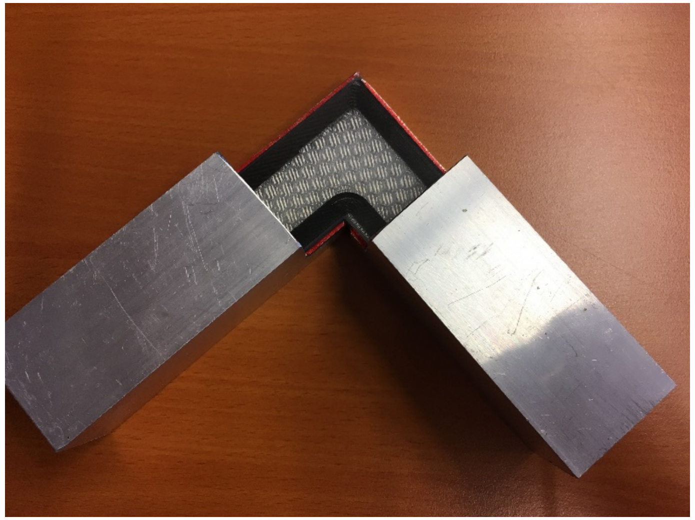




Experiment set-up in the Simulation tool

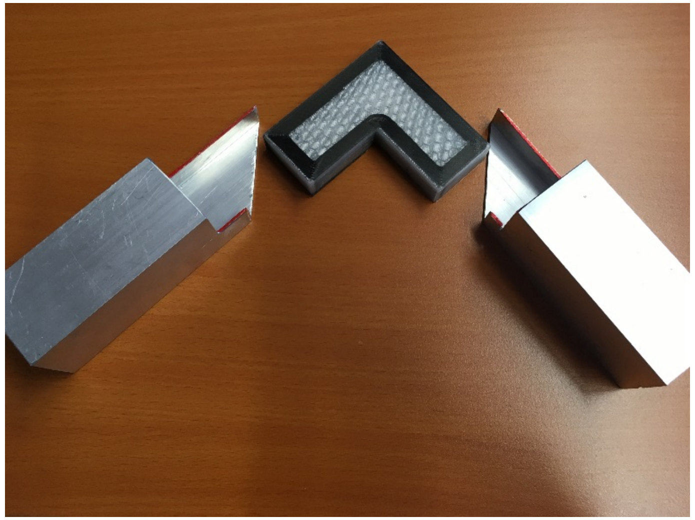


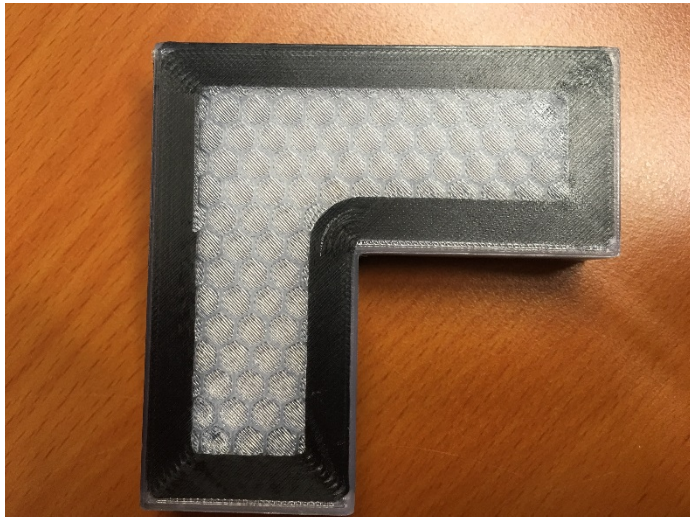
3 Fix concept corner joint



L-profile in housing. Housing protects laminate from impacts.

Must be glued to the housing.





Concentric orientation of the reinforced fibers allows a derivative of the forces.

Honeycomb structure for a good energy absorbiong.

3 Printed Corners

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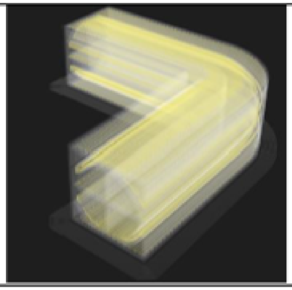
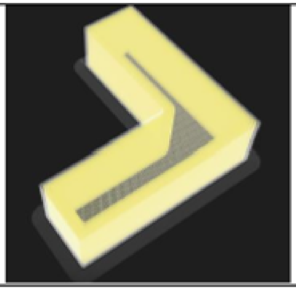
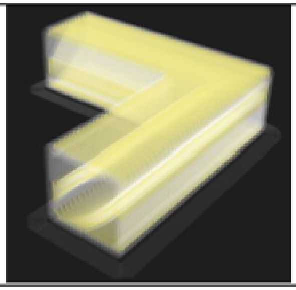
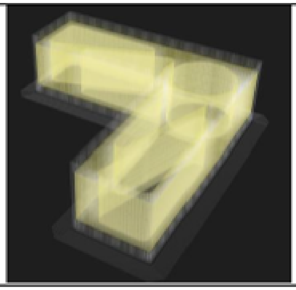
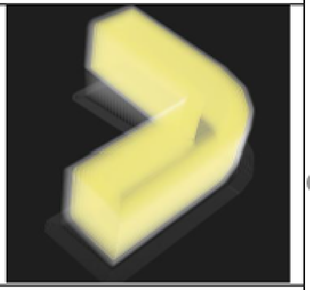
Part Details Mark Two	Dimensions 80.0mm x 80.0mm x 26.0mm Print Time 16h 10m Material Cost 33.22 USD Final Part Mass 59.73g Plastic Volume 44.99 cm³ Fiber Volume 15.81 cm³	Dimensions 80.0mm x 80.0mm x 26.0mm Print Time 14h 18m Material Cost 57.77 USD Final Part Mass 88.89g Plastic Volume 31.18 cm³ Fiber Volume 34.12 cm³	Dimensions 80.0mm x 80.0mm x 26.0mm Print Time 18h 43m Material Cost 47.62 USD Final Part Mass 78.56g Plastic Volume 46.16 cm³ Fiber Volume 25.24 cm³	Dimensions 80.0mm x 80.0mm x 26.0mm Print Time 20h 30m Material Cost 65.28 USD Final Part Mass 93.24g Plastic Volume 26.99 cm³ Fiber Volume 39.72 cm³	Dimensions 80.2mm x 82.8mm x 39.5mm Print Time 18h 43m Material Cost 72.60 USD Final Part Mass 102.24g Plastic Volume 36.55 cm³ Fiber Volume 43.25 cm³
Internal View					
Beschreibung Faserlage	oben/mitte/unten: black metal	oben/unten: black metal, mittig: 5 konzentrische Ringe	oben/unten: 0° Lagen	oben/unten: (0/18/90/72) Lagen	7 konzentrische Ringe mit Bauteilrotation
Gewicht (Messung)	69,5 g	80 g	74 g	82,5 g	90 g
Max. Biegekraft	816,5 N	1116,5 N	800 N	2361 N	1744 N
Max. Biege-Torsionskraft	636 N	642 N	461 N	932,5 N	770 N
Spezifische Biegekraft	11,7 N/g	13,9 N/g	10,8 N/g	28,6 N/g	19,3 N/g
Spezifische Biege-Torsionskraft	9,1 N/g	8 N/g	6,2 N/g	11,2 N/g	8,5 N/g
Wertung (Punkte)	2/5 P | 4/5 P | 3.	3/5 P | 2/5 P | 4.	1/5 P | 1/5 P | 5.	5/5 P | 5/5 P | 1.	4/5 P | 3/5 P | 2.

Abb.3) Evaluation of the flexural and flexural-torsional test

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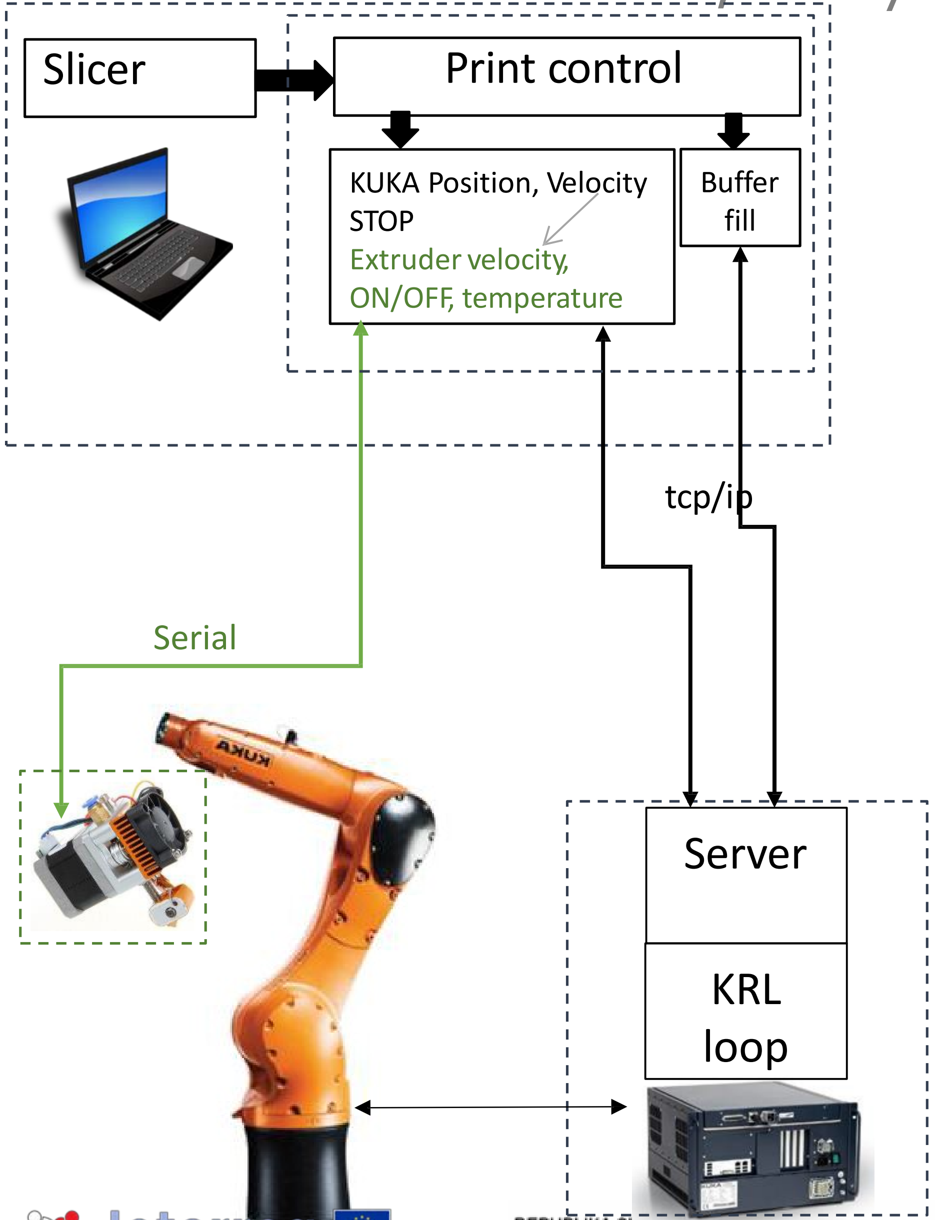
4 Roboterzelle

4 Software – Print control, everything from PC



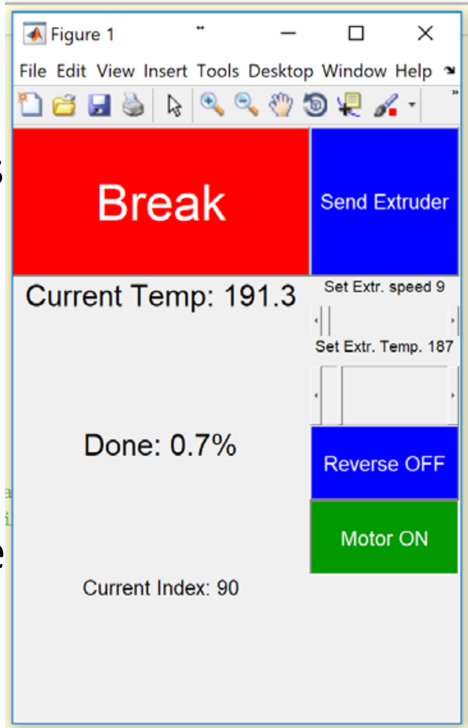
Client/Server architecture:

- Time critical communication has a dedicated connection and a dedicated parallel process (positions, velocities, orientations, interrupts extruder switching and speeds)

- Buffer filling non-critical

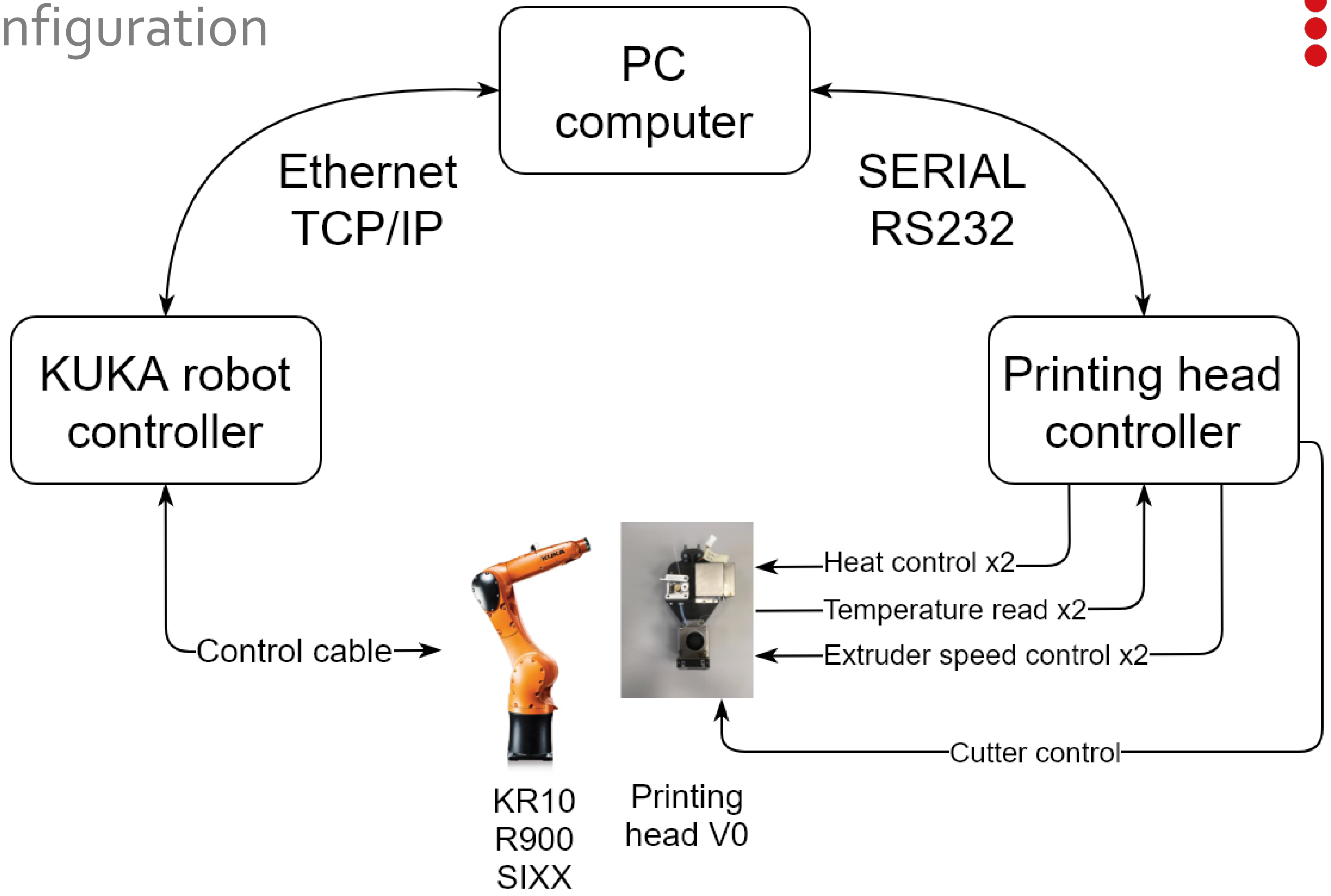
- Kuka controller looping through data (positions, velocities, interrupts) at min cycle time (12ms)

- Safe stopping if communication breaks, workspace monitoring…



5 Roboter-Printer-Ensemble

5 Control configuration



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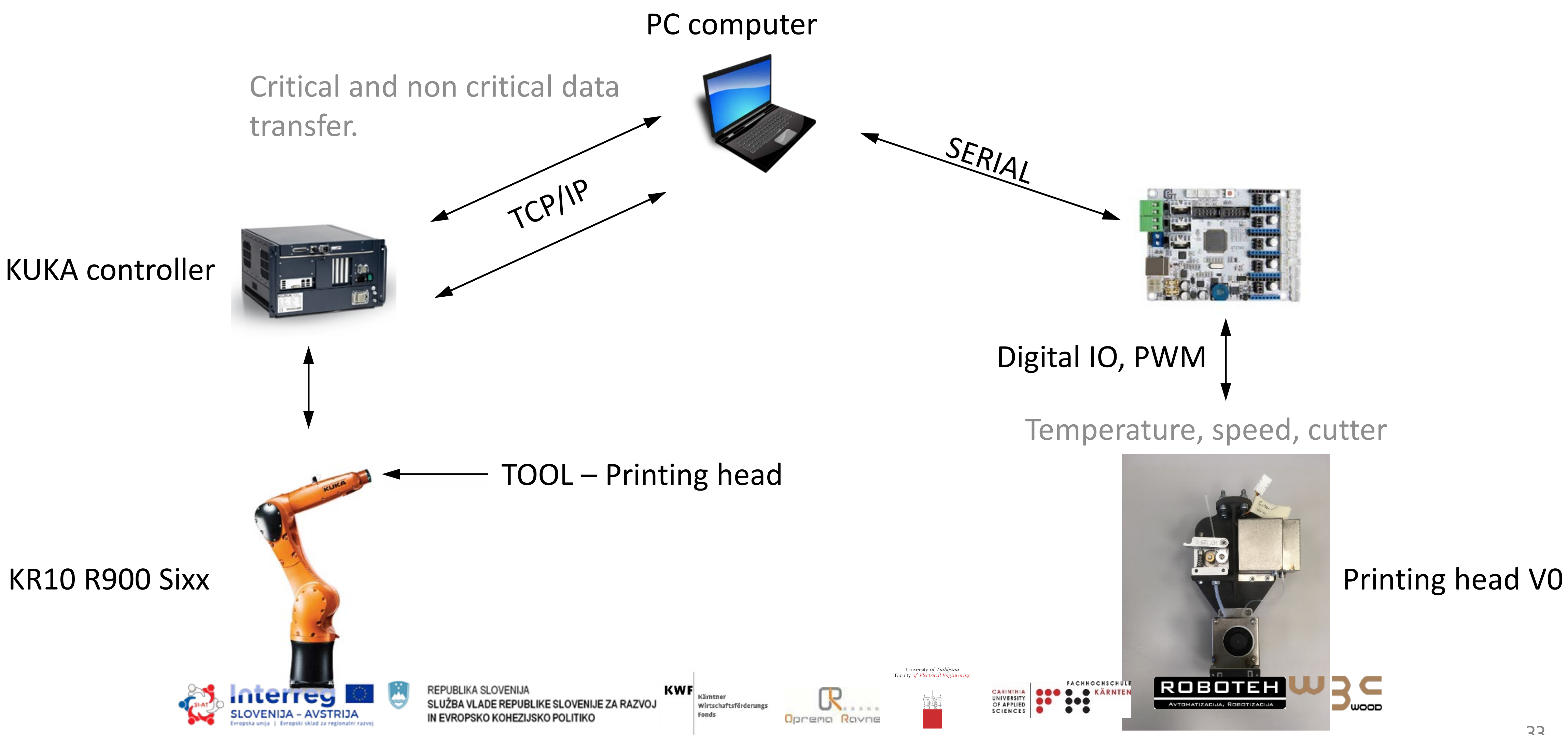
SLUŽBA VLADE REPUBLIKE SLOVENIJE ZA RAZVOJ IN EVROPSKO KOHEZIJSKO POLITIKO

5 Communication data process



5 Outreach

- Had a small showcase at MOS Celje (trade fair)

- Wrote a conference article and presented our approach to curved slicing and path planning, ERK Portorož

Curved slicing and path planning methods for additive manufacturing

David Kraljic[1], Roman Kamnik[1]

[1] Fakulteta za Elektrotehniko, Univerza v Ljubljani
E-mail: David.Kraljic@fe.uni-lj.si

Abstract

Curved layer slicing is a new approach to additive manufacturing that aims to build objects in terms of curved layers, thus improving the strength and surface quality of the finished product. We present a new method of curved layer slicing by translating the geometrical problem of slicing to an optimization one, leading to better performance in terms of accuracy and speed than the methods so far. We also develop a new method of path planning on curved surfaces that removes the shortcomings, such as gaps and overlapping of tracks, of previous approaches.

1 Introduction

Fused deposition modeling (FDM) is a form of additive manufacturing that has become an increasingly popular way of producing not only early stage design models and

Figure 1: Finite layer thickness leads to the 'stair-step' effect for curved surfaces.

However, most of the designed objects for FDM have discrete geometries and consist of triangulated surfaces (e.g. in STL format). This leads to a different mathematical problem of optimally slicing such discrete objects into stacks of parallel curved surfaces as well as planning ex-

6 Zusammenfassung

6 Zusammenfassung und Ausblick

- MMO3D Druck Projekt und Motivation → Linien 3D-Druck für beschichtete Fasern für Leichtbau
  - Erste Beschichtungsversuche → 3D-Druckkopfkonzept für Faserverbund 3D-Druck
- Projekt MMO3D mit Länderübergreifenden Konsortialpartnern: 2 Österreich, 3 Slowenien. Anwendungsfall für die Automobilindustrie: Batteriebox.
- 3D-Druckkopfentwicklung – Untersuchung der Druckeigenschaften, Testbench, Druckkopfkonzept, G-Code-Entwicklung für 3D-Druck aufbauend auf Open Source, Zusammenarbeit mit Robotergruppe in Slowenien; Universität in Ljubljana

Ausblick:

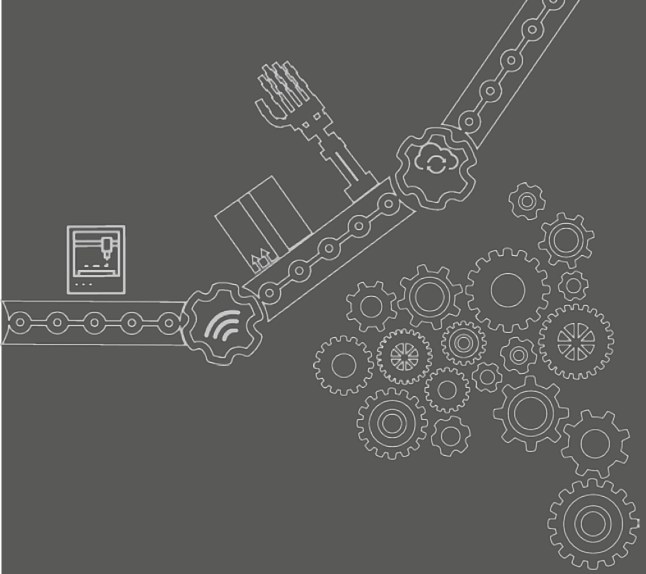
- Weiterentwicklung des Druckkopfes und 3 Dissertationen zum Thema Faserverbunddruck in „immaterial“ group der FH-Kärnten
- Abschlusspublikation des MMO3D-Projektes 2020 mit allen Ergebnissen
- Patenteinreichung geplant

Herzlichen Dank für die Aufmerksamkeit!

FH-Prof. Mag. DI Dr. Bernhard Heiden MBA

Professor for
Production Engineering
b.heiden@fh-kaernten.at

PS.: The presentation is available also at: http://www.dr-heiden.com/Vortraege.htm



Wirtschaftsingenieure verbinden …

Literatur

Literature AM Recommendation

[BeC19] Clarissa Becker et al., "3D Additive Manufacturing of High Performance Composites (AMHPC)," Posterpresentation in 22. Symposium Verbundwerkstoffe und Werkstoffverbunde am 26. - 28. Juni 2019 in Kaiserslautern, 2019.

[LeU16] Ulrich Leitner, 2016, 3-D Druck von Verbundwerkstoffen - Erstellung eines Prozesskonzeptes für glasfaserverstärkten Kunststoff (GFK), Bachelorarbeit, Carinthia University of Applied Sciences, Austria

[ZlM91] Marko Zlokarnik, 1991, Dimensional Analysis and Scale-up in Chemical Engineering, Springer Verlag, Berlin Heidelberg