Appendix

A: Data Sheets

Agilus30

stratasys

PolyJet Rubberlike Material

Agilus30™ is a superior rubber-like PolyJet™ photopolymer family ideal for advanced design verification and colorful rapid prototyping. Get more durable, tear-resistant prototypes that can stand up to repeated flexing and bending and design validation. With a Shore A value of 30 in all Agilus30 versions you can accurately simulate the precise colorful look, feel and function of rubber-like products. 3D print rubber surrounds,overmolds, soft-touch colorful coatings, living hinges, jigs and fixtures, wearables, consumer goods, grips and seals with surface texture.

Mechanical Properties	**Test Method**	**Value**		
		Black / Translucent	White	Cyan/Magenta/Yellow
Tensile Strength	ASTM D-412	2.4 – 3.1 MPa (348 – 450 psi)	2.1-2.6 MPa (305 – 377 psi)	2.2 – 2.6MPa (319-377 psi)
Elongation at Break	ASTM D-412	220 – 270%	185 – 230%	315 - 335%
Compressive Set	ASTM D-395	6 – 7%	6 – 7%	6 – 7%
Tensile Tear Resistance	ASTM D-624	4 – 7 Kg/cm (22 – 39 lb/in)	4 – 7 Kg/cm (22 – 39 lb/in)	4.1-4.4 kg/cm (23-25 lb/in)

Other	**Test Method**	**Value**		
		Black / Translucent	White	Cyan/Magenta/Yellow
Shore Hardness	ASTM D-2240	30 – 35 Scale A	30 – 40 Scale A	28-33 Scale A
Polymerized Density	ASTM D-792	1.14 – 1.15 g/cm³	1.14 – 1.15 g/cm³	1.14 – 1.15 g/cm³

System Availability	**Layer Thickness Capability**	**Support Structure**	**Available Color**
Objet260/350/500 Connex1/2/3™	High Speed mode: 30 microns (0.0012 in.)	SUP705 (WaterJet removable) SUP706B (soluble + WaterJet removable)	☐ Translucent ■ Black
Stratasys J735™/ Stratasys J750™	High Speed mode: 27 microns (0.0011 in.)	SUP705 (WaterJet removable) SUP706B (soluble + WaterJet removable)	■ Black ☐ Translucent ☐ White ■ Cyan ■ Magenta ■ Yellow
J4100™	High Speed mode: 27 microns (0.001 in.)	SUP705 (WaterJet removable)	■ Black ☐ Translucent
J826™ Prime / J835™ Prime / J850™ Prime / J850 Pro	High Quality mode: 14 microns (0.00055 in.) High Mix mode: 27 microns (0.001 in.) High Speed mode: 27 microns (0.0011 in.)	SUP705 (WaterJet removable) SUP706B (soluble + WaterJet removable)	■ Black ☐ Translucent ☐ White ■ Cyan ■ Magenta ■ Yellow

Stratasys Ltd. (2022). *PolyJet rubberlike material* [Data Sheet]. https://www.stratasys.com/contentassets/1e715cc6ffe641cd9415e9631c17e192/mds_pj_agilus30_cmy_a4_1122a.pdf?v=4ab3d5

VeroUltra for Stratasys J55

VeroUltra™ includes VeroUltra™ WhiteS and VeroUltra™ BlackS colors and is available for the J55 printer. VeroUltra™ is available in 1.1 kg cartridges for the J55 printer. The use of VeroUltra™ WhiteS and VeroUltra™ BlackS improves significantly the color opacity and color uniformity. It also provides a smoother texture enabling high quality plastic appearance, ultra-sharp graphics and high contrast print levels previously impossible to achieve.

Opaque materials facilitate the printing of thin parts, providing richer colors with sharper textures and texts. Opaque shades bring models to life with un-matched color realism.

Vero Opaque for J55
VeroUltra™ WhiteS (RGD824), VeroUltra™ BlackS(RGD864) available in 1.1 kg cartridges

Vero Opaque Family for J55		
	ASTM	**Value**
Tensile Strength	D-638-03	50-65 (7250-9430 psi)
Elongation at Break	D-638-05	5-20 %
Modulus of Elasticity	D-638-04	2000 - 3000 MPa (290000 - 435000 psi)
Flexural Strength	D-790-03	65-85 (9400-12300 psi)
Flexural Modulus	D-790-04	2000-2800 (290000-406100 psi)
HDT, °C @ 0.45MPa	D-648-06	48-52 °C (118-126 °F)
HDT, °C @ 1.82MPa	D-648-07	44-47 °C (111-117 °F)
Izod Notched Impact	D-256-06	20-30 J/m (0.375 – 0.562 ft-lb/in.)
Water Absorption	D-570-98 24hr	1.1-1.4%
Tg	DMA, E»	54-56 °C (124-133 °F)
Shore Hardness (D)	Scale D	83 – 86
Polymerized Density	ASTM D792	1.19-1.23

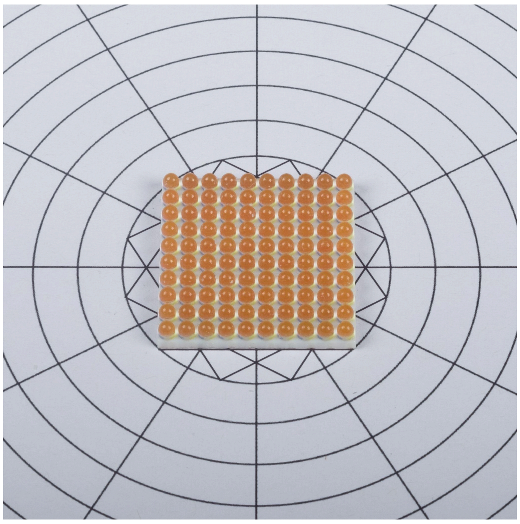
System Availability			
Printer	**Min Layer Thickness**	**Support Structure**	**Available Colors**
J55	18 microns (0.0007 in.)	SUP710 (WaterJet removable)	VeroUltra™ WhiteS VeroUltra™ BlackS

Data sheet - Vero Ultra. (n.d.). https://www.stratasys.com/siteassets/materials/materials-catalog/polyjet-materials/veroultra/mds_pj_veroultra-for-j55_0321b-1.pdf?v=48e03c

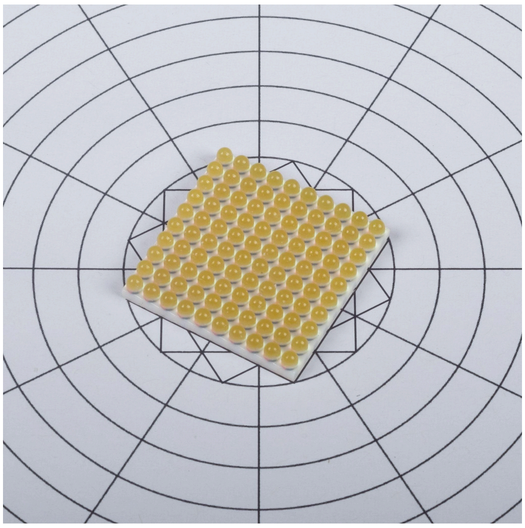
Product Specifications	
Model Materials	Vero™ family of opaque materials including neutral shades and vibrant colors Tango™ family of flexible materials Transparent VeroClear™ and RGD720
Digital Model Materials	Unlimited number of composite materials including: Over 360,000 colors Digital ABS and Digital ABS2™ in ivory and green Rubber-like materials in a variety of Shore A values Translucent color tints
Support Materials	SUP705 (WaterJet removable)
Build Size	490 x 390 x 200 mm (19.3 x 15.35 x 7.9 in.)
Layer Thickness	Horizontal build layers down to 14 microns (0.00055 in.)
Workstation Compatibility	Windows 7 and 8.1
Network Connectivity	LAN - TCP/IP
System Size and Weight	1400 x 1260 x 1100 mm (55.1 x 49.6 x 43.4 in.); 430 kg (948 lbs.) Material Cabinet: 670 x 1,170 x 640 mm (26.4 x 46.1 x 25.2 in.); 152 kg (335 lbs.)
Operating Conditions	Temperature 18-25 °C (64-77 °F); relative humidity 30-70% (non-condensing)
Power Requirements	100–120 VAC, 50–60 Hz, 13.5 A, 1 phase 220–240 VAC, 50–60 Hz, 7 A, 1 phase
Regulatory Compliance	CE, FCC, EAC
Software	PolyJet Studio™ 3D printing software
Build Modes	High Speed: up to 3 base resins, 27-micron (0.001 in.) resolution High Quality: up to 6 base resins, 14-micron (0.00055 in.) resolution High Mix: up to 6 base resins, 27-micron (0.001 in.) resolution
Accuracy	20-85 microns for features below 50 mm; up to 200 microns for full model size (for rigid materials only)
Resolution	X-axis: 600 dpi; Y-axis: 600 dpi; Z-axis: 1800 dpi

Stratasys Ltd. (2016). *THE 3D PRINTING SOLUTIONS COMPANY* [Product brochure]. https://www.biomodel.com/downloads/news_Stratasys-J750-Printer-Spec-Sheet.pdf

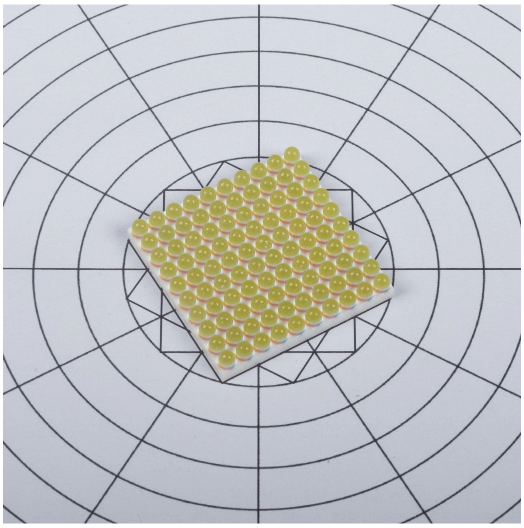
B: Prototype A Results



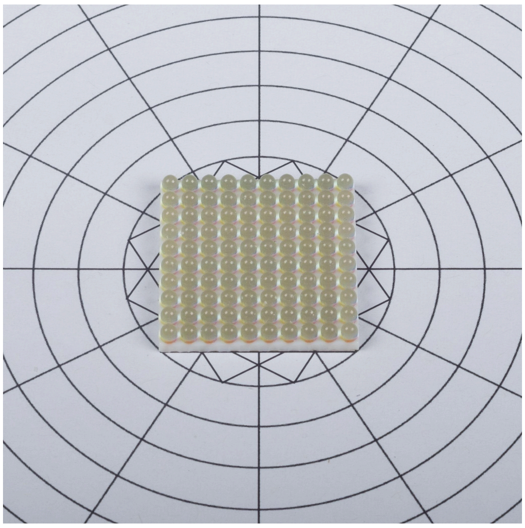
0-40



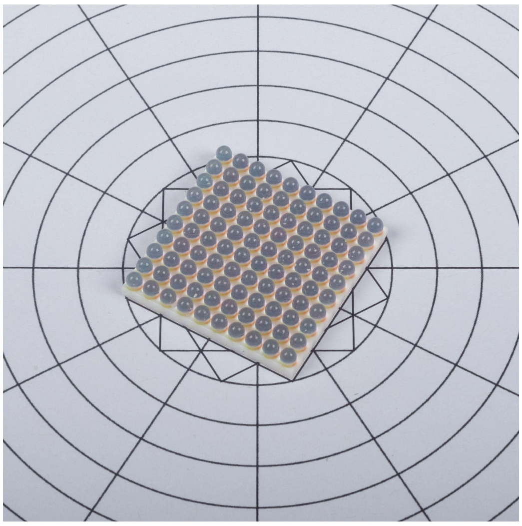
60-40



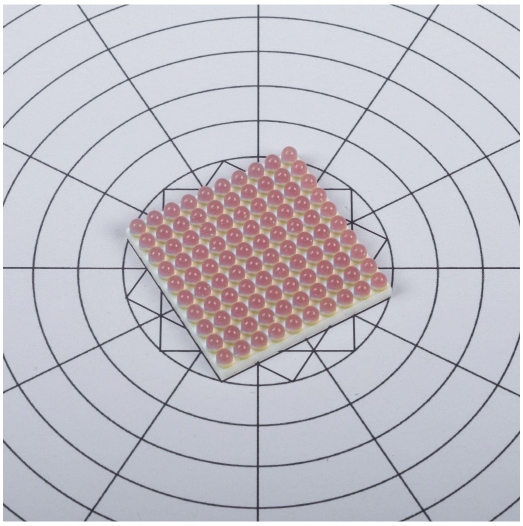
120-40



180-40

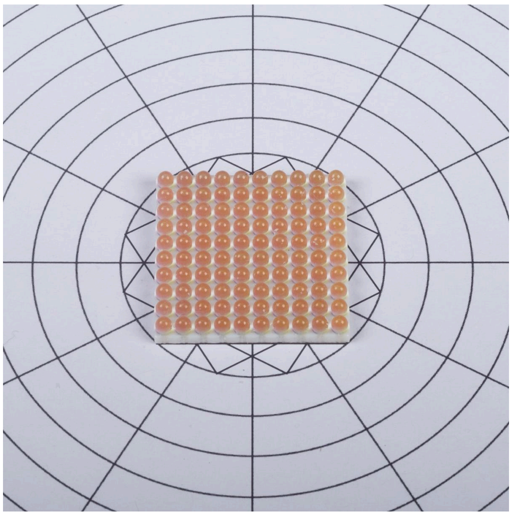


240-40

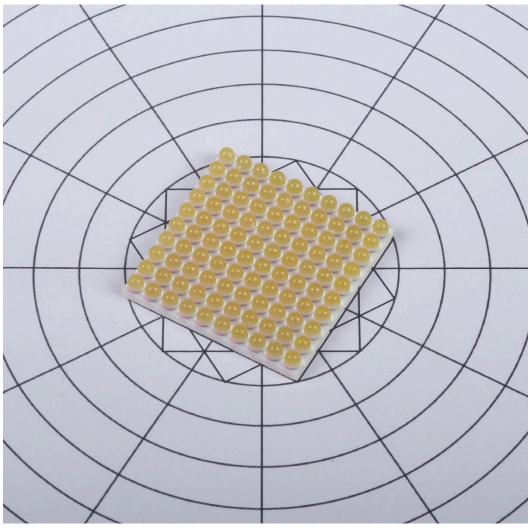


300-40

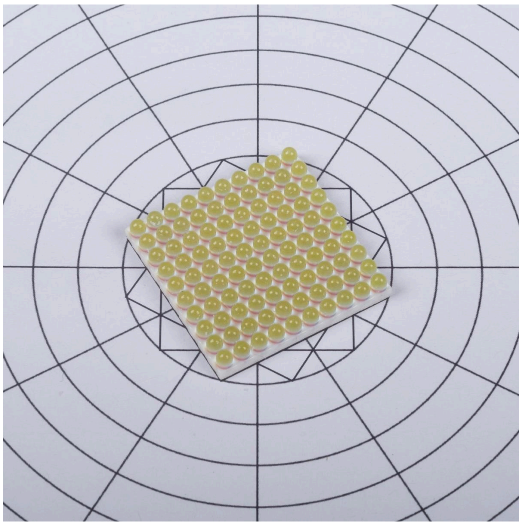
C. Prototype B Results



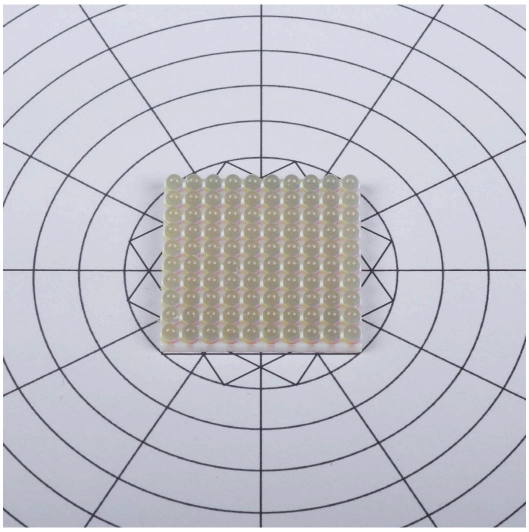
0-40



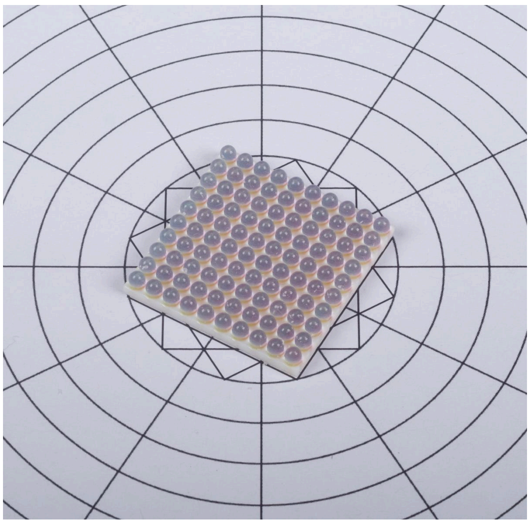
60-40



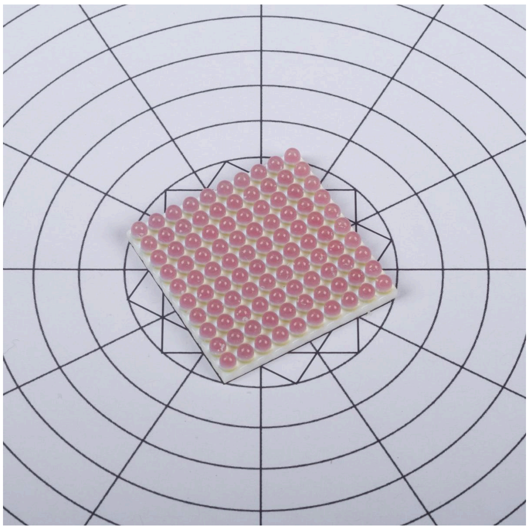
120-40



180-40



240-40



300-40

D. Project Brief

PROJECT TITLE, INTRODUCTION, PROBLEM DEFINITION and ASSIGNMENT
Complete all fields, keep information clear, specific and concise

Project title Exploring the transformative potential of voxel printing in the design of tangible interfaces for mixed reality

Please state the title of your graduation project (above). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

Introduction

Describe the context of your project here; What is the domain in which your project takes place? Who are the main stakeholders and what interests are at stake? Describe the opportunities (and limitations) in this domain to better serve the stakeholder interests. (max 250 words)

While in its early stages of development, the manufacturing technique of voxel printing has shown great potential for future design applications. Through specific dispersement patterns of miniscule droplets of various selected materials, research has shown that material mechanical properties, aesthetics, and consequent behaviour can be manipulated on both micro and macro level, adding another layer of dimensionality to conventional 3D printing techniques.

Through this added dimensionality voxel printing enables unique design opportunities for complex adaptive products where material properties, aesthetics (fig 1) and behaviour (fig 2) can be catered to its designated use case. While this dimensionality enables complex and specific functionalities, little is known about how these functionalities can facilitate and enrich user interaction and experience.

To gain a better understanding of how voxel printing could, and should be used in design a more holistic approach to research is required. Through the methodology "Reseach through Design" a tangible interface for mixed reality will be designed - exploring the potentional and associated challenges of voxel printing for human-computer interfaces through a human-centered lens. For the academic/design community, this research angle has the opportunity to highlight new applications for voxel printing within the domains of human-computer interface- and experience- design. Generated insights can in turn inform future design strategies, guidelines and methodologies for technology-driven innovation.

image / figure 1 Zeng, J. (2020) *"Unream Voxel Printed Lamp" [Photograph].* https://designers.org/104797

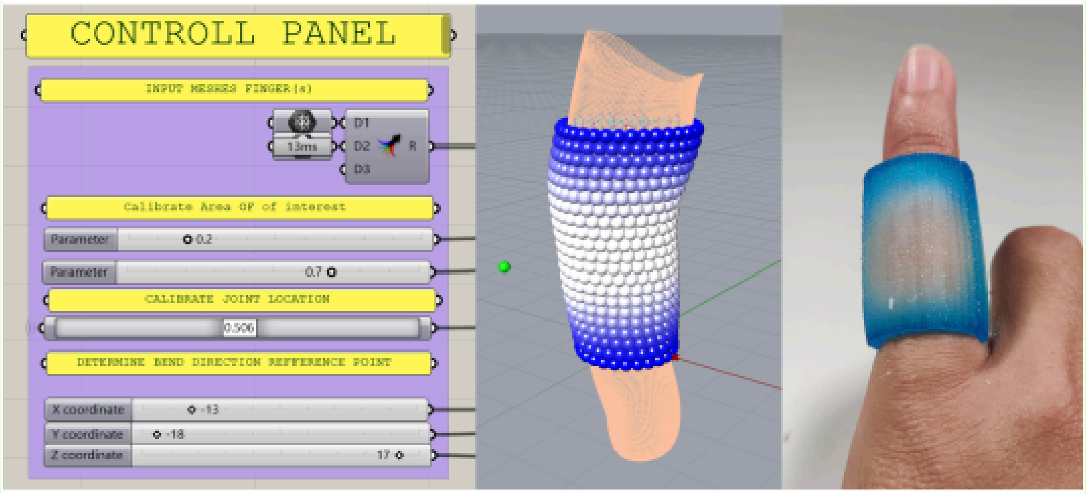


image / figure 2 Previous research: voxel printed brace with programmable bending behaviour for improved revalidation.

Problem Definition

What problem do you want to solve in the context described in the introduction, and within the available time frame of 100 working days? (= Master Graduation Project of 30 EC). What opportunities do you see to create added value for the described stakeholders? Substantiate your choice.
(max 200 words)

The added dimensionality of voxel printing in material properties, shape, texture, and behaviour enables a new realm of possibilities for human-product interactions. As these qualities are not fixed and the material can be manipulated for each individual use-case, each product may behave and perform entirely differently. This potentially brings new design challenges in terms of usability and user experience. Where for conventional production methods generalizeable semantics can be formed based of form and appearance, voxel prints could be vastly different on case to case basis.

Consequently, the use of voxel printing will require new perspectives and considerations for the design of tangible interfaces. Research is required to understand how the unique capabilities can be leveraged while recognizing associated challenges for human-computer interaction.

For the acedemic/design community, the generated insights from the research can inform future designs, methodologies and guidelines, providing new avenues for human-computer interaction paradigms. Furthermore, the explorative nature of the research can uncover new phenomena and anomalies, providing grounds for future independent research.

Assignment

This is the most important part of the project brief because it will give a clear direction of what you are heading for. Formulate an assignment to yourself regarding what you expect to deliver as result at the end of your project. (1 sentence) As you graduate as an industrial design engineer, your assignment will start with a verb (Design/Investigate/Validate/Create), and you may use the green text format:

Investigate how the use of voxel printing can transform the way human-computer interfaces are designed, experienced, and understood through the design of a tangible interface for Mixed Reality.

Then explain your project approach to carrying out your graduation project and what research and design methods you plan to use to generate your design solution (max 150 words)

Within the scope of the project, the primary focus will revolve around exploring and leveraging the unique qualities voxel printing provides while simultaneously addressing associated "human-centered" challenges which the ambiguity of material and technology impose upon its users.

Through the methodology of "Research through Design", these focal points will be continuously researched and reflected upon throughout a holistic process of design. A tangible interface for mixed reality is chosen as a case-study, providing a rich context for experiences, interaction and ergonomic design. The envisioned end result is a series of critical design prototypes/artifacts exhibiting both the applications and implications the use of voxel printing can have within the design of human-computer interfaces.

Motivation and personal ambitions

Explain why you wish to start this project, what competencies you want to prove or develop (e.g. competencies acquired in your MSc programme, electives, extra-curricular activities or other).

Optionally, describe whether you have some personal learning ambitions which you explicitly want to address in this project, on top of the learning objectives of the Graduation Project itself. You might think of e.g. acquiring in depth knowledge on a specific subject, broadening your competencies or experimenting with a specific tool or methodology. Personal learning ambitions are limited to a maximum number of five.
(200 words max)

Throughout my graduation I want to prove and expand upon my comptences as an advanced concept designer. Through the minor Advanced Prototyping I got my first contact with computer generated design and advanced technologies. I came to realize how different approaches to design and manufacturing could completely revolutionize the future of product design and systems.

Following the minor I have followed multiple electives building upon advanced technologies, including the electives "Computational design for digital fabrication", "Digital materials" and "Advanced machine learning for design". These electives allowed me to become more experienced with relevant knowledge and skills like modelling, programming and 3D printing. However, I found due to the limited time and scope of these courses that designs involving such techniques seemed to remain superficial - never quite reaching its full potentional.

To unlock this potential, design vision, user experience, and values need to be accounted for. This intersection highly interests me, therefore I want to strengthen my competences in navigating the complexities related to aligning advanced technology capabilities with human needs. Concretely, implementing qualitative user research I want to improve on.