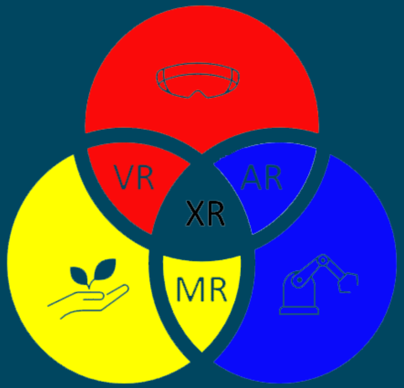
UiT The Arctic University of Norway

Extended Reality Laboratory

XR - LAB



Marius Wang
Department of Industrial Engineering, UiT

Norway grants

VÝSKUMNÁ AGENTÚRA

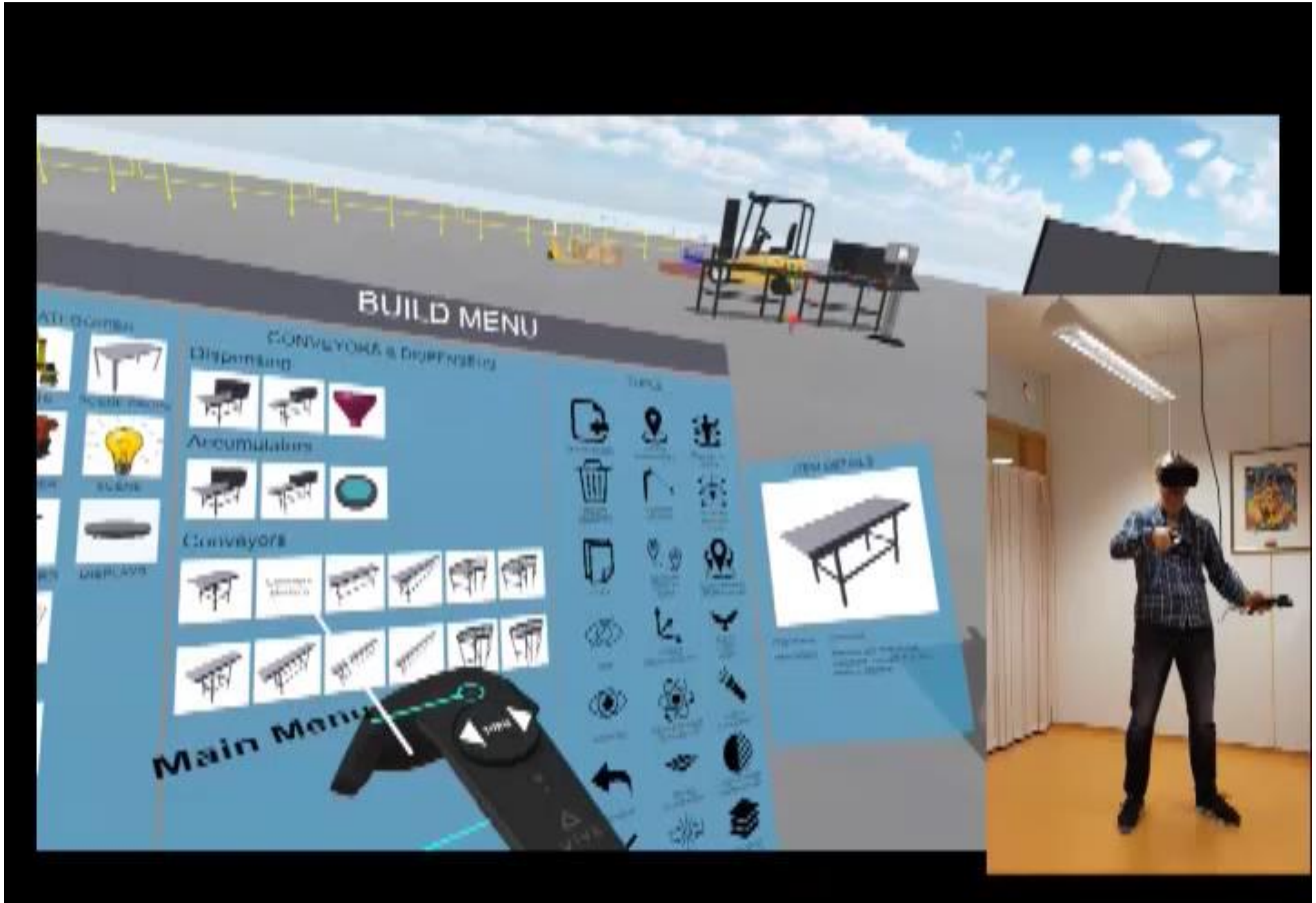
Virtual Reality

HTC VIVE PRO EYE

HTC VIVE

OCULUS QUEST

Virtual Reality



Virtual Reality

Augmentet Reality

Microsoft Hololens 2

AR

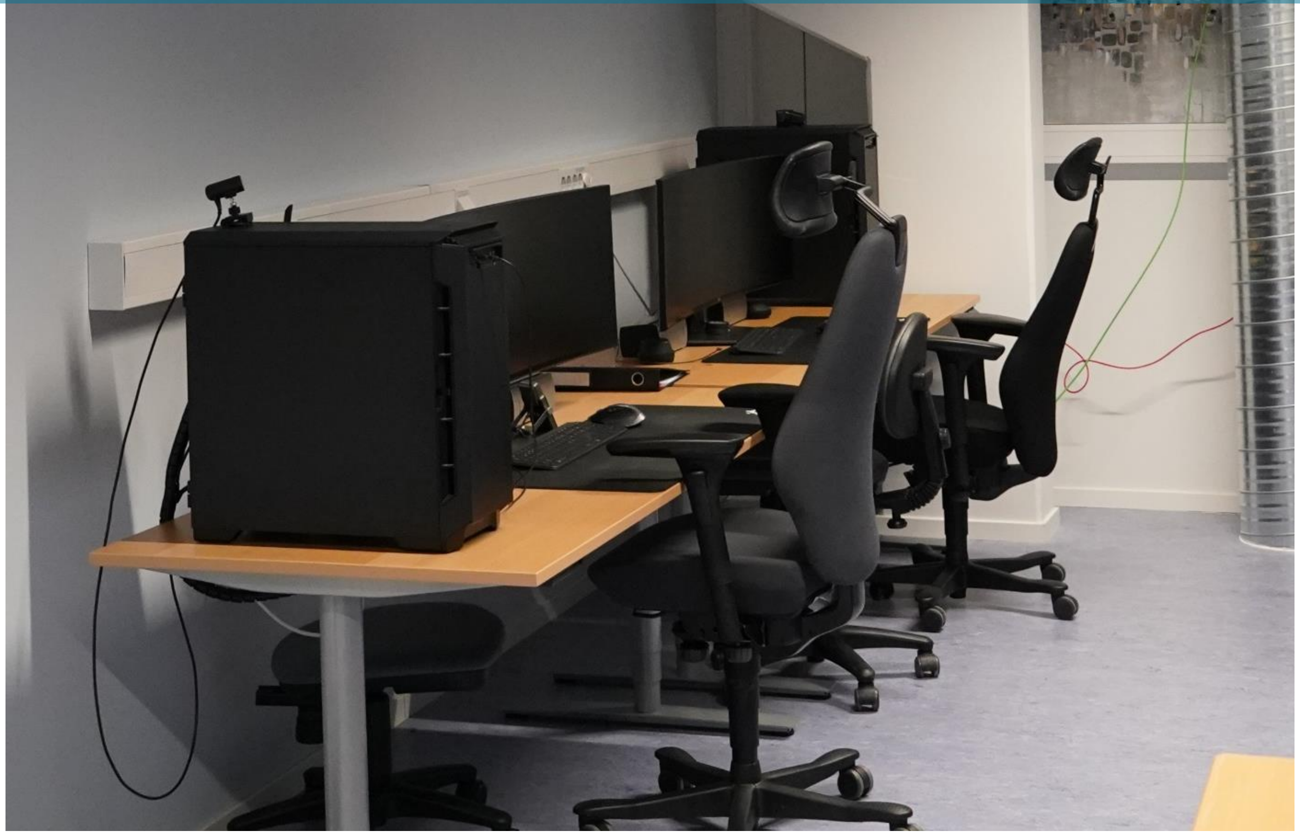
\+ MR

\+ VR

= XR


Explorer
Holographic Remoting
Host App

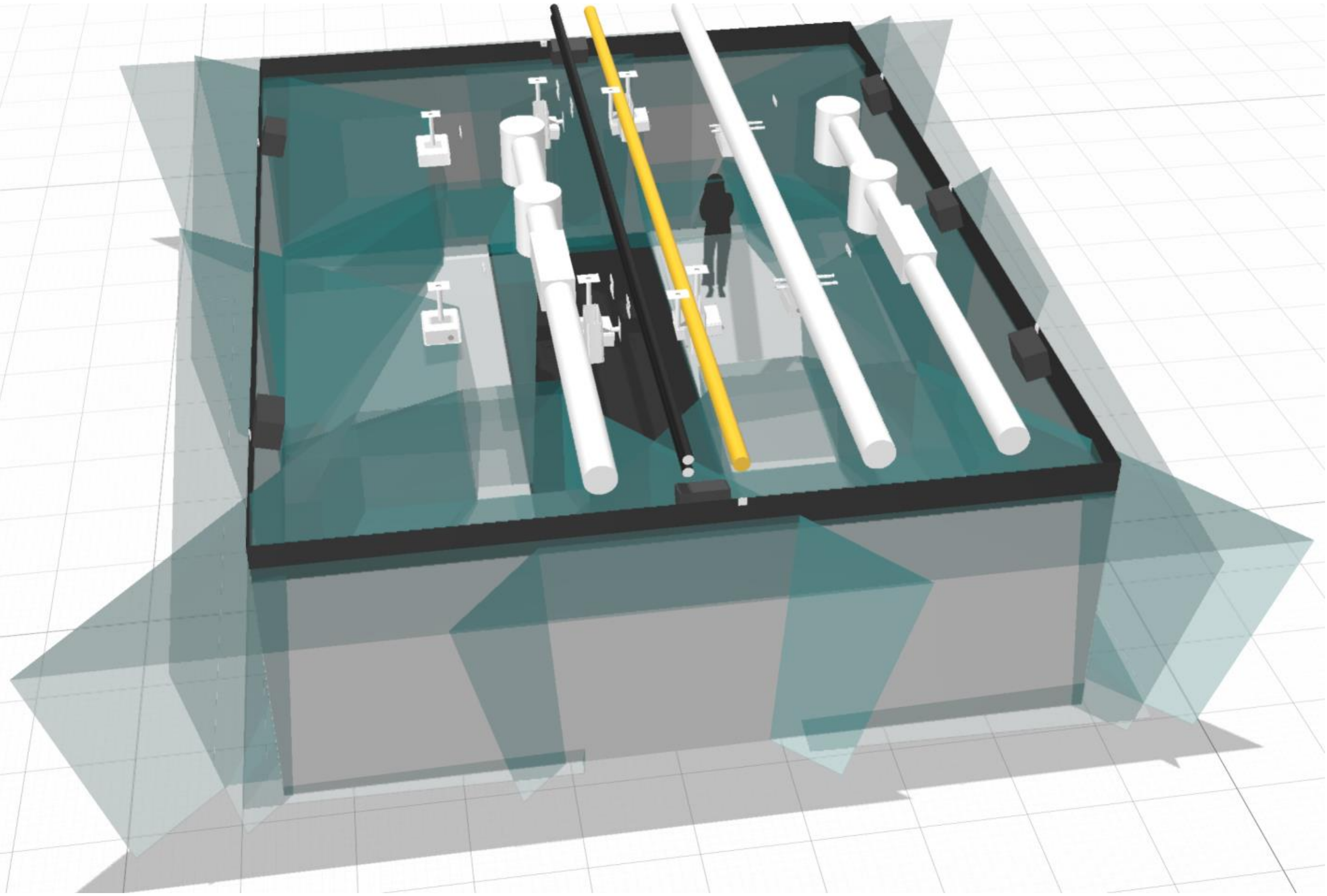
2 computers built for VR and graphics



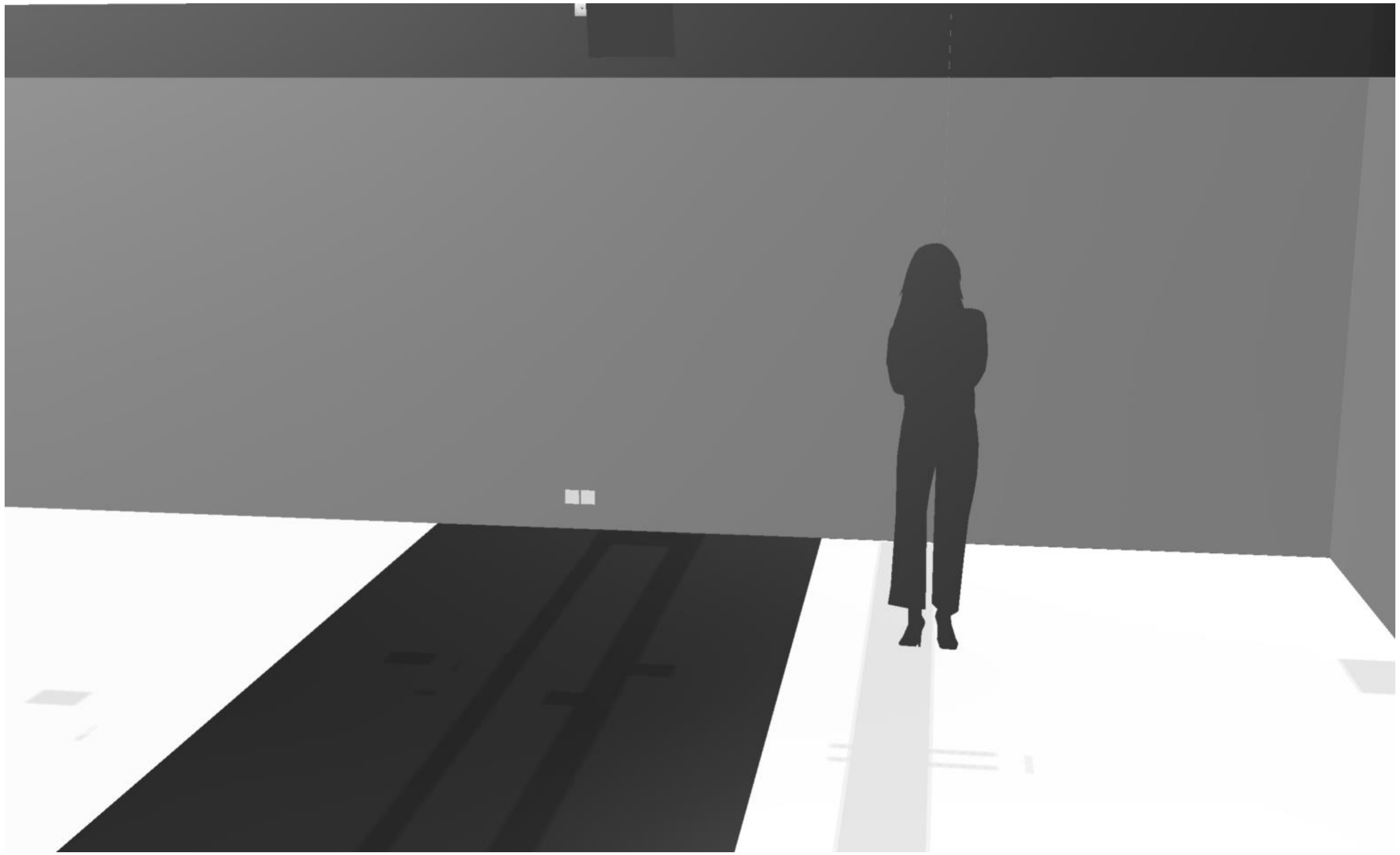
XR – LAB

Extended Reality Laboratory

10 x 7,6 meters



2,5 meters




UiT Norges arktiske universitet
Institutt for industriell teknologi
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VR
AR
XR
MR


Norges
universitet
universitet

VR
AR
XR
MR

VR AR XR MR

VR AR XR MR

VR AR

XR

MR


Idémyldring
Autonom robot som vasker bordoverflater ol.
Automatisk sykkelslangelapper
Koffert uten håndtak
Undervannsdrone for å tette hull på rør
Autonom robbot som trekker deg oppover ... når du ikke har lyst å gå på "topptur"
Robotbukse

VR AR XR MR


Robotbukse
Autonom robot for å kunne lede/passe på f.eks. demente som skal ut å gå.. Avansert kommuniserende førerhund
Autonom handlevogn som følger deg hjem fra butikken

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Additive Manufacturing

Marius Wang
Department of Industrial Engineering, UiT

Norway grants

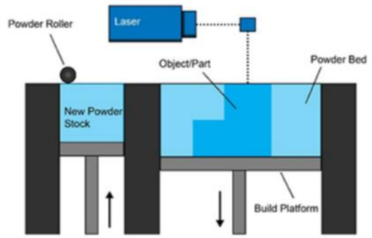
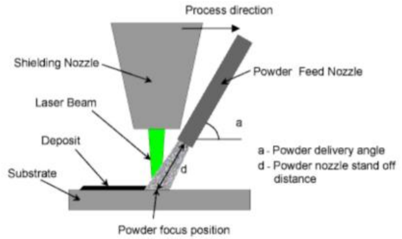
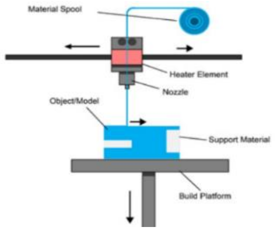
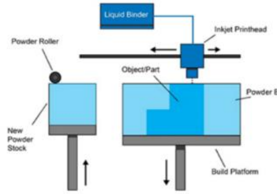
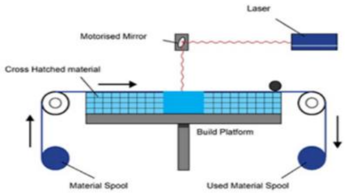
VÝSKUMNÁ AGENTÚRA

AM manufacturing technologies

The large variety of different AM techniques and materials were developed for various applications and needs. Most materials are assigned to certain AM processes, but new and more universal materials are being developed and have the potential to expand out of process specifics.

Metal AM manufacturing methods can be divided into 2 main categories:

- *Melting or softening material*
- *Solid-state joining*

Manufacturing methods	Schematic	Techniques
1. Melting or softening materials		
Laser melting		Powder bed fusion • Selective Laser Melting (SLM) • Selective Laser Sintering (SLS) • Direct Metal Laser Sintering (DMLS) • Electron Beam Manufacturing (EBM)
		Direct energy deposition • Direct Metal Deposition (DMD) • Laser Powder Deposition (LPD) • Selective Laser Cladding (SLC) • Electron Beam Direct Melting (EBDM)
Extrusion process		• Fused Deposition Modelling (FDM) • Robocasting or Direct Ink Writing (DIW) • Shaped Metal Deposition (SMD)
Material and Binder jetting		• Inkjet Printing (IJP) • Ballistic Particle Manufacturing (BPM) • M-Print • Droplet-Based Metal Manufacturing (DMM)
2. Solid-state joining		
Material adhesion		• Laminated Object Manufacturing (LOM)

What affects material choice?

- *Part design, design features*
- *AM machine*
- *Post-processing*
- *Type of industry*
- *Location of the company and customers*
- *Customer needs / market demands*
- *Raw material suppliers*
- *Raw material price*
- *Build volume*
- *Building technology*
- *Build rate*
- *Additional cost*

AM metals

- Stainless steel – *316L, 15-5PH, 17-4PH (630)*
- Tool steel – *H13, A2, D2, Maraging 300, Maraging 2*
- *Steel*
- Titanium
- Aluminium – AlSi12, AlSi10Mg
- Copper
- Bronze
- Cobalt Chrome - *Co28Cr6Mo*
- Titanium alloys - *Ti6AI4V, Ti6AL-4V ELI*
- Nickel Alloys – Inconel 625, 713, 718, 738
- Gold
- Silver
- Platinum
- Palladium

Common AM alloys and applications

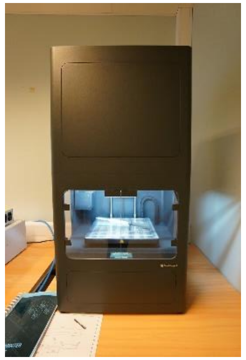
Applications / Alloys	Aluminium	Maraging steel	Stainless steel	Titanium	Cobalt chrome	Nickel alloys	Precious metals
Aerospace	x		x	x	x	x	
Medical			x	x	x		x
Energy, oil and gas			x				
Automotive	x		x	x			
Marine			x	x			
Machinability and weld ability	x		x	x		x	
Corrosion resistance			x	x	x	x	
High temperature			x	x		x	
Tools and moulds		x	x				
Consumer products	x		x				x

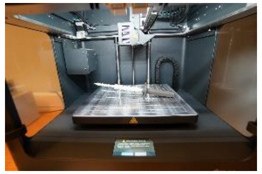
Progress in Materials Science
Additive manufacturing of metallic components –Process, structureand properties
T. DebRoya,⇑, H.L. Wei a, J.S. Zubacka, T. Mukherjeea, J.W. Elmer b, J.O. Milewskic, A.M. Beesea, A. Wilson-Heid a, A. Ded, W. Zhang e

Our metal AM equipment

Metal X

Metal X by Markforged with ADAM (Atomic Diffusion Additive Manufacturing) technology. Metal X manufactures parts from filament roll with metal powder bound in a plastic matrix. The material is fed through a nozzle, like in desktop printers, and laid down layer by layer on the building platform. The printed part is submerged into debinder (Wash-1) for wax binder material removal. The last stage of the manufacturing is done in the furnace (Sinter-1) where the part is sintered to fuse powder into solid metal (≈ 99%).

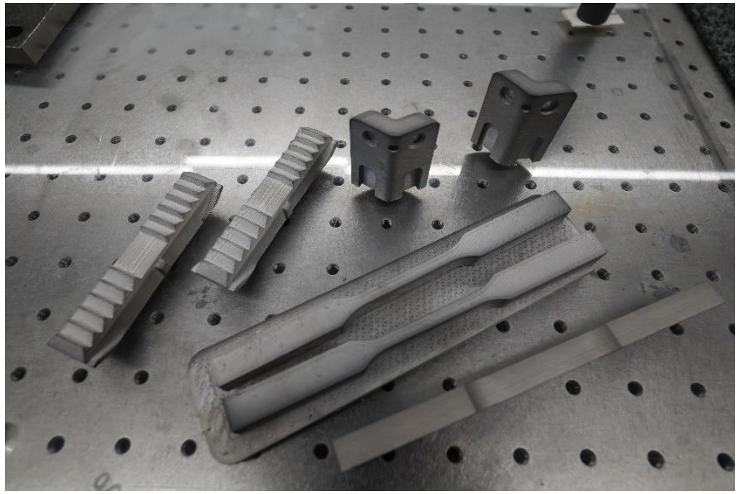


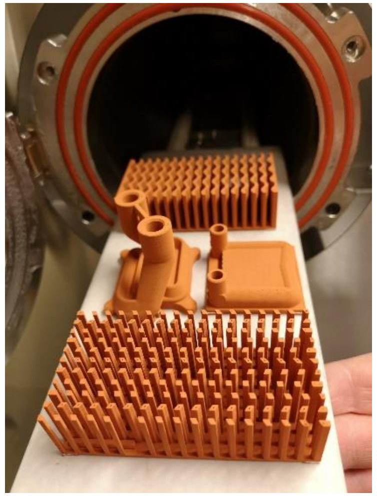
Print volume XYZ:	*300 mm x 220 mm x 180 mm*
Max part size:	*250 x 183 x 150 mm, 10 kg*
Print chamber:	*Heated*
Print system:	*2 nozzles, metal material and support release, 0.4 mm*
Layer resolution:	*0.1 – 0.4 mm*
Dimensional accuracy:	*±0.3mm*
Resolution:	*50 - 200 micron*
Max hot end T °C:	*300 °C*
Build surface material:	*Vacuum sealed print sheet*
Max build surface T °C:	*120 °C*
Levelling:	*Automatic table levelling*
Material diameter:	*3.00 mm*
Build materials:	***Stainless steel 17-4 PH, H13 tool steel, A2 tool steel, Copper,** Inconel 625, D2 tool steel*
Support material:	*Build material with a ceramic release layer*
Firmware:	*Eiger*
Supported file formats:	*.stl*
Furnace volume:	*Cylindrical ø140×305 mm*
Max temperature:	*1300 °C*
Washing size:	*356×254×203 mm*
Washer volume:	*18 356 ccm*
Washing fluid:	*Opteon Sion*

Markforged materials – Mechanical Properties

Name	Hardness	Tensile strength [MPa]	Yield strength [MPa]	Elongation at break [%]	Relative density [%]
Stainless steel 17-4	HRC 36 (HRC 33-40)	1250 (1190 - 1310)	1100 (1090 - 1170)	6 (6-10)	96
A2 tool steel	HRC 50-63	-	1170	1	94.5-100
H13 tool steel	HRC 40-46	1420-1580	800-1360	5-14	94.5-100
Copper	HRC -	193-207	26-69	30-45	98
D2 tool steel	HRC 55-62	-	1690-220	-	97-100
Inconel 625	HRC 7-19	765-827	334-414	30-42	96.5-100

Examples of parts manufactured with the Metal X at the UiT Narvik





Matsuura LUMEX Avance-60 SLM Hybrid

This machine combines an advanced fusion of laser technology (laser selective sintering) and high-precision cutting technology (3-axis milling) enabling the whole new level of manufacturing. Machining operations during AM process (every 10th layer) allow to produce near net shape products with complex interior and exterior geometries, amazing surface finish and dramatically reduce production times.

AM part	***SLS, Yb Fiber laser 1000W. water-cooled***
Print volume XYZ:	*600 mm x 600 mm x 500 mm*
Max part size:	*600 x 600 x 500 mm, 1300 kg*
Print chamber:	*Heated, sealed, Nitrogen filled*
Laser oscillator output range:	*100 - 960 W*
Laser wavelength:	*1070 ± 5 nm*
Layer resolution:	*0.1 – 0.4 mm*
Laser beam focus diameter:	*0.1 – 0.6 mm*
Layer thickness:	*0.05 mm*
Scan speed:	*5.0 m/s*
Build table:	*Heated, 40-120 °C*
Ordered build materials:	***Stainless 630,*** *Stainless 316L Aluminum AlSi10Mg, Maraging Ⅱ, Cobalt Chrome, Titanium 6Al4V, Nickel alloy 718*
Gas supply:	*Argon, Nitrogen, Air*
Machining part	*High-speed milling, 3-axis*
Spindle speed:	*450 – 45000 RPM*
Positioning accuracy XYZ:	*±0.0025 mm*
Repeatability XYZ:	*±0.001 mm*
Tool storage capacity:	*20 pc*
Min tool diameter:	*Ø 0.6 mm*
Max tool diameter:	*Ø 10 mm*
Operating system:	*Fanuc*

Matsuura Powders – Mechanical Properties

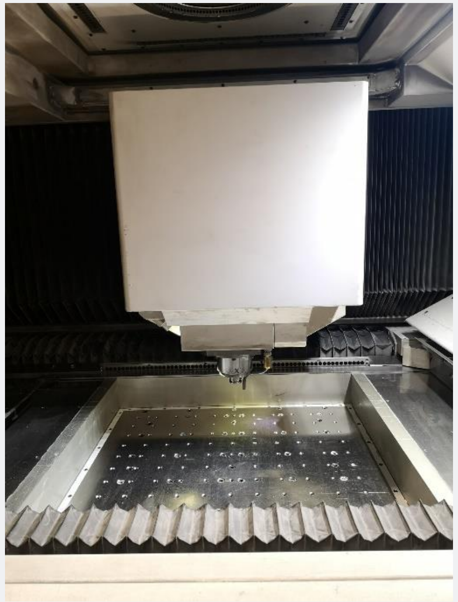
Name	Comparable to	Particle size [µm]	Hardness	Tensile strength [MPa]	Yield strength [MPa]	Elongation at break [%]	Relative density [%]	Build rate [cm^3/h]
Maraging 2	1.2709	20-45	HRC 36 ± 1	1150 - 1200	1000 -1100	11 ± 1	≥ 99,5	7-11
Titanium Ti 6Al4V	3.7165	10-45	HRC 48	460 – 530	420	1	≥ 99,5	4-8
Stainless 630	1.4542	10-45	HRC 32 ± 1	1070 - 1080	830 - 850	17 ± 1	≥ 99,5	7-11
Stainless 316 L	1.4404	10-45	HV 200 ± 10	570 – 580	420-460	32,2 ± 2	≥ 99,5	7-11
Cobalt Chrome	Co-Cr	20-45	HRC 36 ± 1	1170 – 1200	870-900	15 ± 2	≥ 99,5	6-10
Nickel Alloy 718	2.4668	10-45	HRC 27 ± 1	930 - 980	650-690	22 ± 5	≥ 99,5	7-11
Aluminum Si10 Mg	AlSi10Mg	20-63	HBW 99 ± 3	400 – 420	220 - 240	8 ± 1	≥ 99,5	9-13

Hybrid Additive Manufacturing on the Matsuura LUMEX Avance-60

Machine architecture:

Selective Laser Melting/Powder Bed Fusion

+



Highspeed milling

=

LUMEX Avance-60

Hybrid AM:

- *Design freedom of conventional SLM*

+

- *In-process machining of difficult or impossible to reach surfaces*
- *Manufacturing of high-aspect-ratio-features (deep slots, channels…)*
- *Precise reference-/clamping-surfaces for post-processing (e.g. on multi-axis-machining centers)*

Conventional SLM

- *Precision: +/- 0,1 mm (up to +/- 0,05 mm)*
- *Surface roughness: R_z 50 µm (up to R_z 25 µm)*

Hybrid AM on LUMEX

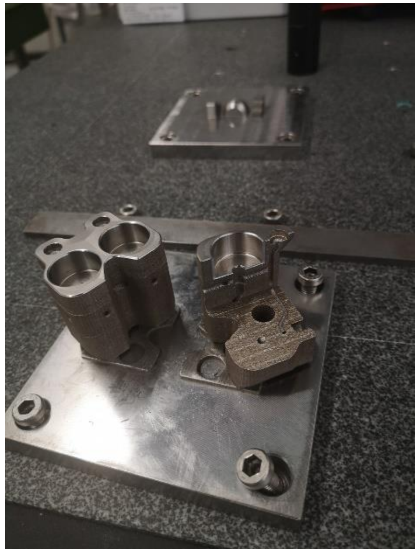
SLM-only:

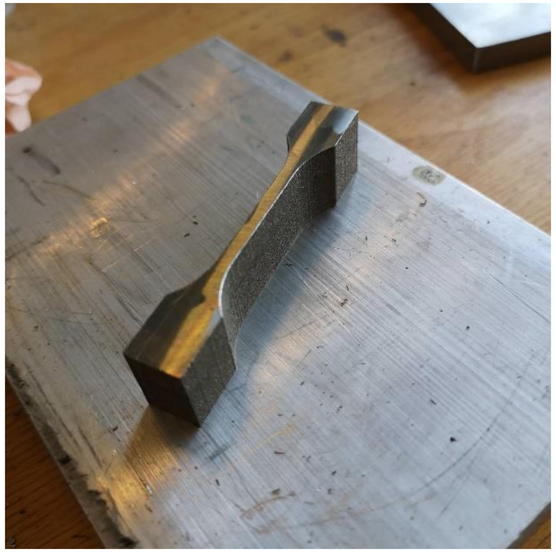
- *Precision: at least +/- 0,1 mm (up to +/- 0,05 mm)*
- *Surface roughness: at least R_z 50 µm (up to R_z 25 µm)*

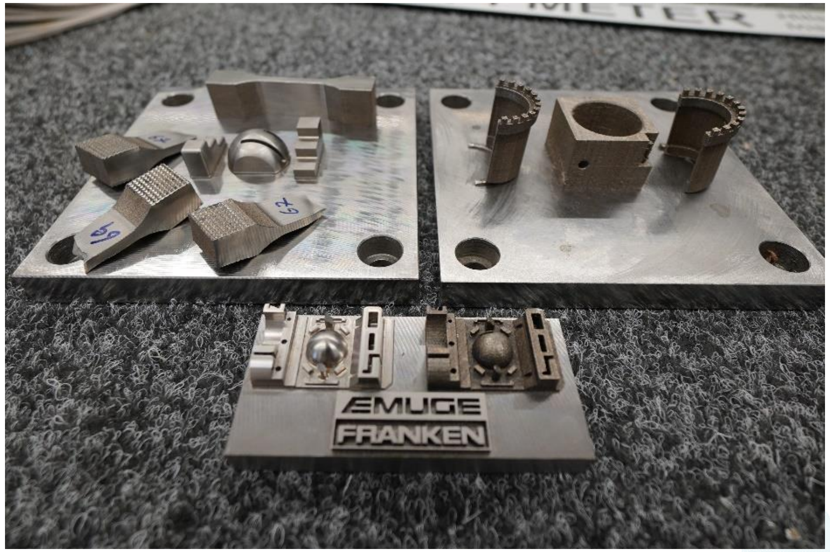
SLM + in-process machining

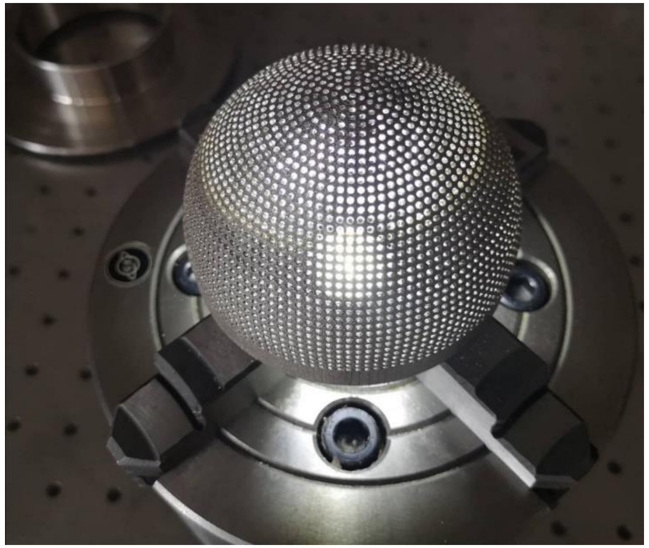
- *Precision: +/- 0,025 mm (up tp +/- 0,005 mm)*
- *Surface roughness: R_z 10 µm (up to R_z 3,5 µm)*

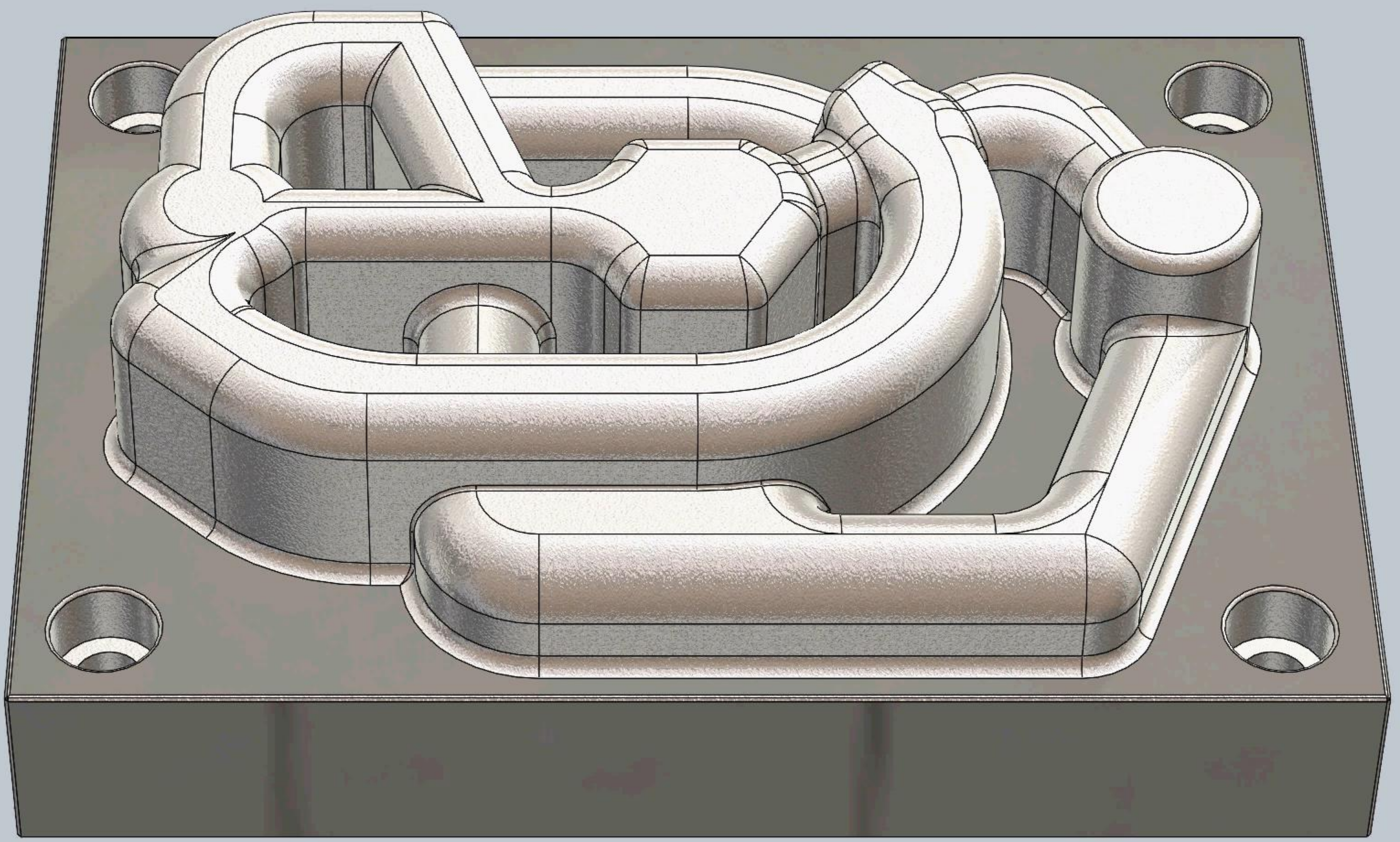
Examples of parts manufactured with the Matsuura Lumex at the UiT Narvik











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Thank you for attention!

Marius Wang
Department of Industrial Engineering, UiT

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